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(54) **Title**: CONJUGATES OF NEUROTENSIN OR NEUROTENSIN ANALOGS AND USES THEREOF

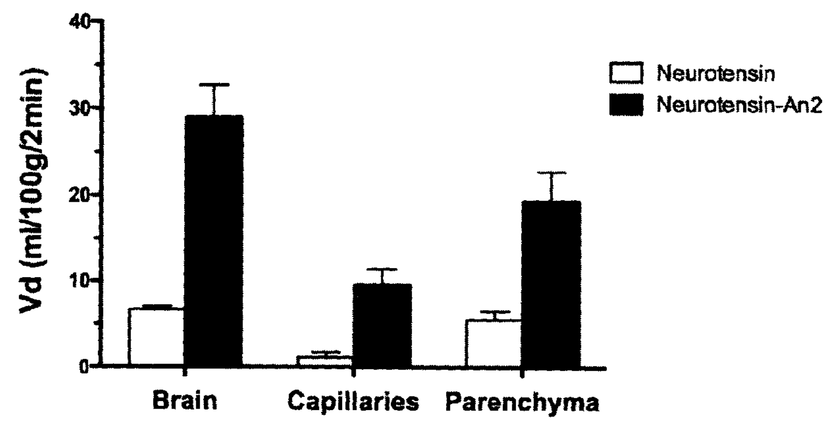

Figure 9

(57) **Abstract**: The present invention features a compound having the formula A-X-B, where A is peptide vector capable of enhancing transport of the compound across the blood-brain barrier or into particular cell types, X is a linker, and B is a peptide therapeutic selected from the group consisting of neurotensin, a neurotensin analog, or a neurotensin receptor agonist. The compounds of the invention can be used to treat any disease in which increased neurotensin activity is useful and can be used to induce hypothermia or analgesia.

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CONJUGATES OF NEUROTENSIN OR NEUROTENSIN ANALOGS AND USES THEREOF

Background of the Invention

The invention relates to compounds including neurotensin, a neurotensin analog, or a neurotensin receptor agonist bound to a peptide vector and uses thereof.

Neurotensin is 13 amino acid peptide possessing numerous biological activities. Injections of neurotensin in the central nervous system produce, among other effects, antipsychotic and hypothermic effects. Intravenous delivery of neurotensin, however, does not result in these effects, as the blood-brain barrier (BBB) effectively prevents peripheral neurotensin from reaching the receptors in the central nervous system (CNS) receptors.

Reduction of body temperature (hypothermia) provides one of the best forms of neuroprotection against brain damage resulting from injury (e.g., in subjects who have suffered from a nerve, brain, or spinal cord injury, or stroke). Prior to the present invention, methods for reducing body temperature have been inadequate. Physical means for reducing body temperature include the use of external methods (e.g., cooling blankets, cooling helmet, ice packs, and ice baths) as well as the use of internal methods (e.g., cooling probes, infusion of cold fluid). These techniques can be complex and expensive, and can lead to delays in the onset of hypothermia. Sustained maintenance of hypothermia may also be difficult using these methods. Finally, these methods can cause severe shivering, necessitating the need for co-medications such as paralytic agents or sedatives. Given the number of strokes (795,000), cardiac arrests of cardiac origin (325,000), severe traumatic head injuries (300,000), and open heart surgeries (694,000) each year in the United States where hypothermic treatment can be beneficial, there is a need for improved methods of inducing hypothermia.

In the development of a new therapy for brain pathologies, the BBB is considered a major obstacle for the potential use of drugs for treating disorders of the CNS. The global market for CNS drugs was $68 billion in 2006, which was roughly half that of global market for cardiovascular drugs, even though in the United States, nearly twice as many people suffer from CNS disorders as from cardiovascular

diseases. The reason for this imbalance is, in part, that more than 98% of all potential CNS drugs do not cross the BBB. In addition, more than 99% of worldwide CNS drug development is devoted solely to CNS drug discovery, and less than 1% is directed to CNS drug delivery. This may explain the lack of therapeutic options available for major neurological diseases.

The brain is shielded against potentially toxic substances by the presence of two barrier systems: the BBB and the blood-cerebrospinal fluid barrier (BCSFB). The BBB is considered to be the major route for the uptake of serum ligands since its surface area is approximately 5000-fold greater than that of BCSFB. The brain endothelium, which constitutes the BBB, represents the major obstacle for the use of potential drugs against many disorders of the CNS. As a general rule, only small lipophilic molecules may pass across the BBB, i.e., from circulating systemic blood to brain. Many drugs that have a larger size or higher hydrophobicity show high efficacy in CNS targets but are not efficacious in animals as these drugs cannot effectively cross the BBB. Thus, peptide and protein therapeutics are generally excluded from transport from blood to brain, owing to the negligible permeability of the brain capillary endothelial wall to these drugs. Brain capillary endothelial cells (BCECs) are closely sealed by tight junctions, possess few fenestrae and few endocytic vesicles as compared to capillaries of other organs. BCECs are surrounded by extracellular matrix, astrocytes, pericytes, and microglial cells. The close association of endothelial cells with the astrocyte foot processes and the basement membrane of capillaries are important for the development and maintenance of the BBB properties that permit tight control of blood-brain exchange.

Thus, there exists a need for improved delivery of neurotensin to its target sites.

Summary of the Invention

The peptide neurotensin has a number of clinical uses, including the ability to reduce body temperature. Many of these applications, however, require that the peptide cross the blood-brain barrier (BBB).

Neurotensin, by itself, is unable to cross the BBB. We have therefore synthesized compounds that include (a) a polypeptide therapeutic selected from the group consisting of neurotensin, a neurotensin analog (e.g., pELYENKPRRPYIL-OH,

where "pE" represents L-pyroglutamic acid, human neurotensin(8-13) (NT(8-13)), Ac-Lys-[D-Tyr^{11}]NT(8-13), Ac-Lys-NT(8-13), pE-Lys-NT(8-13),), or a neurotensin receptor agonist and (b) a peptide vector capable of transporting the peptide therapeutic across the blood-brain barrier (BBB) or into particular cell types. These compounds are useful in treating any disorder where increased neurotensin activity is desired, particularly where transport of the polypeptide therapeutic across the BBB or into a particular cell type is desired. In one particular example, the compound includes neurotensin or a neurotensin fragment which may be used to reduce body temperature (e.g., in a patient who is in need of neuroprotection and/or has had a stroke, heart attack, nerve injury (e.g., spinal chord, head, or brain injury, such as a traumatic brain injury, or is having major surgery such as cardiac surgery or open heart surgery), to treat a patient suffering from a psychiatric disorder (e.g., schizophrenia, obsessive compulsive disorder, or Tourette's syndrome), or to treat a patient suffering from a metabolic disorder such as diabetes and obesity. In other cases, the compound may be able to either increase or reduce blood pressure in a patient. The compound may be capable of inducing hypothermia, upon either a single or upon an infusion for a period of at least 1, 2, 3, 4, 6, 8, 10, 12, 15, 18, 21, 24, 30, 36, or 48 hours following initial administration. The peptide vector is capable of transporting the polypeptide therapeutic either across the blood-brain barrier (BBB) or into a particular cell type (e.g., liver, lung, kidney, spleen, and muscle). Because the conjugates are targeted across the BBB or to particular cell types, therapeutic efficacy can be achieved using lower doses or less frequent dosing as compared to the unconjugated peptide therapeutic, thus reducing the severity of or incidence of side effects and/or increasing efficacy. The compound may also exhibit increased stability, improved pharmacokinetics, or reduced degradation in vivo, as compared to the unconjugated peptide therapeutic.

Accordingly, in a first aspect the invention features a compound having the formula:

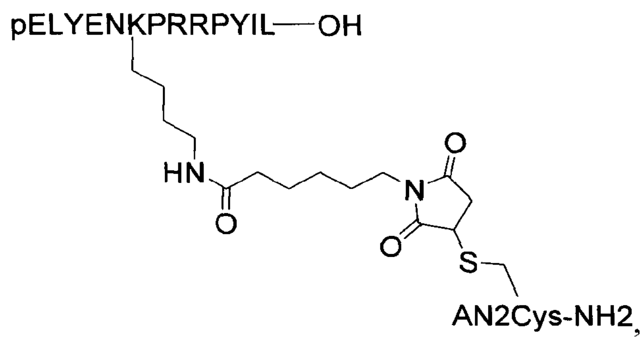
A-X-B

where A is a peptide vector capable of being transported across the blood-brain barrier (BBB) or into a particular cell type (e.g., liver, lung, kidney, spleen, and muscle), X is a linker, and B is a peptide therapeutic selected from the group consisting of neurotensin, a neurotensin analog (e.g., pELYENKPRRPYIL-OH,

where pE is pyroglutamic acid), or a neurotensin receptor agonist (e.g., any of those described herein). The transport across the BBB or into the cell may be increased by at least 10%, 25%, 50%, 75%, 100%, 200%, 500%, 750%, 1000%, 1500%, 2000%, 5000%, or 10,000%. The compound may be substantially pure. The compound may be formulated with a pharmaceutically acceptable carrier (e.g., any described herein).

In certain embodiments, B includes or is a polypeptide substantially identical to human neurotensin or to a human neurotensin fragment (e.g., neurotensin(8-13) and neurotensin(9-13)). In certain embodiments, the glutamate at position 1 of neurotensin is substituted with pyroglutamic acid. In certain embodiments, the neurotensin analog is substantially identical to human neurotensin. In certain embodiments, B acts as an agonist to any of the neurotensin receptors (neurotensin receptor type 1 (NTR1), neurotensin receptor type 2 (NTR2), neurotensin receptor 3 (NTR3)). In certain embodiments, the neurotensin receptor agonist is selective (e.g., binds and/or activates to a degree at least 2, 5, 10, 50, 100, 500, 1000, 5000, 10,000, 50,000, or 100,000 greater) for one of NTR1, NTR2, or NTR3 over at least one of the other receptors.

In particular embodiments, the compound has the structure:



where the $-(CH_2)_4NH-$ moiety attached to the lysine of the pELYENKPRRPYIL sequence represents the side chain of that lysine, and the $-CH_2S-$ moiety attached to the C-terminal cysteine of the AN2Cys sequence represents the side chain of that cysteine, and AN2 represents the sequence of Angiopep-2 (SEQ ID NO:97).

In another aspect, the invention features methods of making the compound A-X-B. In one embodiment, the method includes conjugating the peptide vector (A) to a linker (X), and conjugating the peptide vector-linker (A-X) to a peptide therapeutic (B), thereby forming the compound A-X-B. In another embodiment, the method includes conjugating the peptide therapeutic (B) to a linker (X), and conjugating the

peptide therapeutic/linker (X-B) to a peptide vector (A), thereby forming the compound A-X-B. In another embodiment, the method includes conjugating the peptide vector (A) to a peptide therapeutic (B), where either A or B optionally include a linker (X), to form the compound A-X-B.

In another aspect, the invention features a nucleic acid molecule that encodes the compound A-X-B, where the compound is a polypeptide. The nucleic acid molecule may be operably linked to a promoter and may be part of a nucleic acid vector. The vector may be in a cell, such as a prokaryotic cell (e.g., bacterial cell) or eukaryotic cell (e.g., yeast or mammalian cell, such as a human cell).

In another aspect, the invention features methods of making a compound of the formula A-X-B, where A-X-B is a polypeptide. In one embodiment, the method includes expressing a nucleic acid vector of the previous aspect in a cell to produce the polypeptide; and purifying the polypeptide.

In another aspect, the invention features a method of reducing a subject's body temperature. The method includes administering a compound of the first aspect in an amount sufficient to reduce the body temperature of the subject. The subject may be suffering from, or may have recently suffered from, a stroke, cerebral ischemia, cardiac ischemia, or a nerve injury such as a brain injury (e.g., a traumatic brain injury) or a spinal chord injury or may be in need of neuroprotection. The subject may be suffering from malignant hyperthermia or may be undergoing or about to undergo surgery (e.g., major surgery such as cardiac surgery).

In another aspect, the invention features a method of reducing pain or inducing analgesia by administering in a compound of the first aspect to a subject in need thereof. The subject may be suffering from an acute pain (e.g., selected from the group consisting of mechanical pain, heat pain, cold pain, ischemic pain, and chemical-induced pain). In other embodiments, the subject is suffering from peripheral or central neuropathic pain, inflammatory pain, migraine-related pain, headache-related pain, irritable bowel syndrome-related pain, fibromyalgia-related pain, arthritic pain, skeletal pain, joint pain, gastrointestinal pain, muscle pain, angina pain, facial pain, pelvic pain, claudication, postoperative pain, post traumatic pain, tension-type headache, obstetric pain, gynecological pain, or chemotherapy-induced pain.

In another aspect, the invention features a method of reducing pain sensitivity in a subject by administering a compound (e.g., an effective amount) of the first aspect to a subject.

In another aspect, the invention features a method of treating (e.g., prophylactically) a metabolic disorder in a subject. The method includes administering a compound of the first aspect of the invention to a subject in an amount sufficient to treat the metabolic disorder. The metabolic disorder may be diabetes (e.g., Type I or Type II), obesity, diabetes as a consequence of obesity, hyperglycemia, dyslipidemia, hypertriglyceridemia, syndrome X, insulin resistance, impaired glucose tolerance (IGT), diabetic dyslipidemia, hyperlipidemia, a cardiovascular disease, or hypertension. The subject may be overweight, obese, or bulimic.

In another aspect, the invention features a method of treating (e.g., prophylactically) a disorder selected from the group consisting of anxiety, obsessive-compulsive disorder, Tourette's syndrome, movement disorder, aggression, psychosis, seizures, panic attacks, hysteria, sleep disorders, Alzheimer's disease, and Parkinson's disease. The method includes administering a compound of the first aspect of the invention to a subject in an amount sufficient to treat or prevent the disorder. The psychosis may be schizophrenia.

In another aspect, the invention features a method of treating drug addiction or reducing drug abuse in a subject in need thereof. The drug may be a psychostimulant such as amphetamine, methamphetamine, 3,4-methylenedioxymethamphetamine, nicotine, cocaine, methylphenidate, or arecoline. In other embodiments, the drug is alcohol.

In another aspect, the invention features a method of modulating (e.g., increasing or decreasing) blood pressure in a subject (e.g., a subject suffering from either hypertension or hypotension).

In any of the methods involving administration of a compound to a subject, the amount sufficient may be less than 90%, 75%, 50%, 40%, 30%, 20%, 15%, 10%, 5%, 4%, 3%, 2%, 1%, or 0.1% of the amount required for an equivalent dose of the polypeptide therapeutic (e.g., any described herein) when not conjugated to the peptide vector. The amount sufficient may reduce a side effect as compared to

administration of an effective amount of the polypeptide therapeutic when not conjugated to the peptide vector. The subject may be a mammal such as a human.

In any of the above aspects, the peptide vector may be a polypeptide substantially identical to any of the sequences set Table 1, or a fragment thereof. In certain embodiments, the peptide vector has a sequence of Angiopep-1 (SEQ ID NO:67), Angiopep-2 (SEQ ID NO:97), Angiopep-3 (SEQ ID NO:107), Angiopep-4a (SEQ ID NO:108), Angiopep-4b (SEQ ID NO:109), Angiopep-5 (SEQ ID NO:110), Angiopep-6 (SEQ ID NO:111), or Angiopep-7 (SEQ ID NO:112)). The peptide vector or conjugate may be efficiently transported into a particular cell type (e.g., any one, two, three, four, or five of liver, lung, kidney, spleen, and muscle) or may cross the mammalian BBB efficiently (e.g., Angiopep-1, -2, -3, -4a, -4b, -5, and -6). In another embodiment, the peptide vector or conjugate is able to enter a particular cell type (e.g., any one, two, three, four, or five of liver, lung, kidney, spleen, and muscle) but does not cross the BBB efficiently (e.g., a conjugate including Angiopep-7). The peptide vector may be of any length, for example, at least 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 25, 35, 50, 75, 100, 200, or 500 amino acids, or any range between these numbers. In certain embodiments, the peptide vector is 10 to 50 amino acids in length. The polypeptide may be produced by recombinant genetic technology or chemical synthesis.

Table 1: Exemplary Peptide Vectors

SEQ ID NO:	
1	T F V Y G G C R A K R N N F K S A E D
2	T F Q Y G G C M G N G N N F V T E K E
3	P F F Y G G C G G N R N N F D T E E Y
4	S F Y Y G G C L G N K N N Y L R E E E
5	T F F Y G G C R A K R N N F K R A K Y
6	T F F Y G G C R G K R N N F K R A K Y
7	T F F Y G G C R A K K N N Y K R A K Y
8	T F F Y G G C R G K K N N F K R A K Y
9	T F Q Y G G C R A K R N N F K R A K Y
10	T F Q Y G G C R G K K N N F K R A K Y
11	T F F Y G G C L G K R N N F K R A K Y
12	T F F Y G G S L G K R N N F K R A K Y
13	P F F Y G G C G G K K N N F K R A K Y
14	T F F Y G G C R G K G N N Y K R A K Y
15	P F F Y G G C R G K R N N F L R A K Y

16	T F F Y G G C R G K R N N F K R E K Y
17	P F F Y G G C R A K K N N F K R A K E
18	T F F Y G G C R G K R N N F K R A K D
19	T F F Y G G C R A K R N N F D R A K Y
20	T F F Y G G C R G K K N N F K R A E Y
21	P F F Y G G C G A N R N N F K R A K Y
22	T F F Y G G C G G K K N N F K T A K Y
23	T F F Y G G C R G N R N N F L R A K Y
24	T F F Y G G C R G N R N N F K T A K Y
25	T F F Y G G S R G N R N N F K T A K Y
26	T F F Y G G C L G N G N N F K R A K Y
27	T F F Y G G C L G N R N N F L R A K Y
28	T F F Y G G C L G N R N N F K T A K Y
29	T F F Y G G C R G N G N N F K S A K Y
30	T F F Y G G C R G K K N N F D R E K Y
31	T F F Y G G C R G K R N N F L R E K E
32	T F F Y G G C R G K G N N F D R A K Y
33	T F F Y G G S R G K G N N F D R A K Y
34	T F F Y G G C R G N G N N F V T A K Y
35	P F F Y G G C G G K G N N Y V T A K Y
36	T F F Y G G C L G K G N N F L T A K Y
37	S F F Y G G C L G N K N N F L T A K Y
38	T F F Y G G C G G N K N N F V R E K Y
39	T F F Y G G C M G N K N N F V R E K Y
40	T F F Y G G S M G N K N N F V R E K Y
41	P F F Y G G C L G N R N N Y V R E K Y
42	T F F Y G G C L G N R N N F V R E K Y
43	T F F Y G G C L G N K N N Y V R E K Y
44	T F F Y G G C G G N G N N F L T A K Y
45	T F F Y G G C R G N R N N F L T A E Y
46	T F F Y G G C R G N G N N F K S A E Y
47	P F F Y G G C L G N K N N F K T A E Y
48	T F F Y G G C R G N R N N F K T E E Y
49	T F F Y G G C R G K R N N F K T E E D
50	P F F Y G G C G G N G N N F V R E K Y
51	S F F Y G G C M G N G N N F V R E K Y
52	P F F Y G G C G G N G N N F L R E K Y
53	T F F Y G G C L G N G N N F V R E K Y
54	S F F Y G G C L G N G N N Y L R E K Y
55	T F F Y G G S L G N G N N F V R E K Y
56	T F F Y G G C R G N G N N F V T A E Y
57	T F F Y G G C L G K G N N F V S A E Y
58	T F F Y G G C L G N R N N F D R A E Y
59	T F F Y G G C L G N R N N F L R E E Y

60 T F F Y G G C L G N K N N Y L R E E Y
61 P F F Y G G C G G N R N N Y L R E E Y
62 P F F Y G G S G G N R N N Y L R E E Y
63 M R P D F C L E P P Y T G P C V A R I
64 A R I I R Y F Y N A K A G L C Q T F V Y G
65 Y G G C R A K R N N Y K S A E D C M R T C G
66 P D F C L E P P Y T G P C V A R I I R Y F Y
67 T F F Y G G C R G K R N N F K T E E Y
68 K F F Y G G C R G K R N N F K T E E Y
69 T F Y Y G G C R G K R N N Y K T E E Y
70 T F F Y G G S R G K R N N F K T E E Y
71 C T F F Y G C C R G K R N N F K T E E Y
72 T F F Y G G C R G K R N N F K T E E Y C
73 C T F F Y G S C R G K R N N F K T E E Y
74 T F F Y G G S R G K R N N F K T E E Y C
75 P F F Y G G C R G K R N N F K T E E Y
76 T F F Y G G C R G K R N N F K T K E Y
77 T F F Y G G K R G K R N N F K T E E Y
78 T F F Y G G C R G K R N N F K T K R Y
79 T F F Y G G K R G K R N N F K T A E Y
80 T F F Y G G K R G K R N N F K T A G Y
81 T F F Y G G K R G K R N N F K R E K Y
82 T F F Y G G K R G K R N N F K R A K Y
83 T F F Y G G C L G N R N N F K T E E Y
84 T F F Y G C G R G K R N N F K T E E Y
85 T F F Y G G R C G K R N N F K T E E Y
86 T F F Y G G C L G N G N N F D T E E E
87 T F Q Y G G C R G K R N N F K T E E Y
88 Y N K E F G T F N T K G C E R G Y R F
89 R F K Y G G C L G N M N N F E T L E E
90 R F K Y G G C L G N K N N F L R L K Y
91 R F K Y G G C L G N K N N Y L R L K Y
92 K T K R K R K K Q R V K I A Y E E I F K N Y
93 K T K R K R K K Q R V K I A Y
94 R G G R L S Y S R R F S T S T G R
95 R R L S Y S R R R F
R
96 Q I K I W F Q N R R M K W K K
97 T F F Y G G S R G K R N N F K T E E Y
98 M R P D F C L E P P Y T G P C V A R I
I R Y F Y N A K A G L C Q T F V Y G G
C R A K R N N F K S A E D C M R T C G G A

99 T F F Y G G C R G K R N N F K T K E Y

100	R F K Y G G C L G N K N N Y L R L K Y
101	T F F Y G G C R A K R N N F K R A K Y
102	N A K A G L C Q T F V Y G G C L A K R N N F E S A E D C M R T C G G A
103	Y G G C R A K R N N F K S A E D C M R T C G G A
104	G L C Q T F V Y G G C R A K R N N F K S A E
105	L C Q T F V Y G G C E A K R N N F K S A
107	T F F Y G G S R G K R N N F K T E E Y
108	R F F Y G G S R G K R N N F K T E E Y
109	R F F Y G G S R G K R N N F K T E E Y
110	R F F Y G G S R G K R N N F R T E E Y
111	T F F Y G G S R G K R N N F R T E E Y
112	T F F Y G G S R G R R N N F R T E E Y
113	C T F F Y G G S R G K R N N F K T E E Y
114	T F F Y G G S R G K R N N F K T E E Y C
115	C T F F Y G G S R G R R N N F R T E E Y
116	T F F Y G G S R G R R N N F R T E E Y C

Polypeptides Nos. 5, 67, 76, and 91, include the sequences of SEQ ID NOS:5, 67, 76, and 91, respectively, and are amidated at the C-terminus.
Polypeptides Nos. 107, 109, and 110 include the sequences of SEQ ID NOS:97, 109, and 110, respectively, and are acetylated at the N-terminus.

In any of the above aspects, the peptide vector may include an amino acid sequence having the formula:

X1-X2-X3-X4-X5-X6-X7-X8-X9-X10-X11-X12-X13-X14-X15-X16-X17-X18-X19

where each of X1-X19 (e.g., X1-X6, X8, X9, X11-X14, and X16-X19) is, independently, any amino acid (e.g., a naturally occurring amino acid such as Ala, Arg, Asn, Asp, Cys, Gln, Glu, Gly, His, Ile, Leu, Lys, Met, Phe, Pro, Ser, Thr, Trp, Tyr, and Val) or absent and at least one (e.g., 2 or 3) of X1, X10, and X15 is arginine. In some embodiments, X7 is Ser or Cys; or X10 and X15 each are independently Arg or Lys. In some embodiments, the residues from X1 through X19, inclusive, are substantially identical to any of the amino acid sequences of any one of SEQ ID NOS:1-105 and 107-116 (e.g., Angiopep-1, Angiopep-2, Angiopep-3, Angiopep-4a, Angiopep-4b, Angiopep-5, Angiopep-6, and Angiopep-7). In some embodiments, at least one (e.g., 2, 3, 4, or 5) of the amino acids X1-X19 is Arg. In some

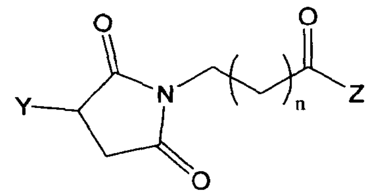
embodiments, the polypeptide has one or more additional cysteine residues at the N-terminal of the polypeptide, the C-terminal of the polypeptide, or both.

In certain embodiments of any of the above aspects, the peptide vector or polypeptide therapeutic is modified (e.g., as described herein). The peptide or polypeptide may be amidated, acetylated, or both. Such modifications may be at the amino or carboxy terminus of the polypeptide. The peptide or polypeptide may also include peptidomimetics (e.g., those described herein) of any of the polypeptides described herein. The peptide or polypeptide may be in a multimeric form, for example, dimeric form (e.g., formed by disulfide bonding through cysteine residues).

In certain embodiments, the peptide vector or polypeptide therapeutic (e.g., neurotensin) has an amino acid sequence described herein with at least one amino acid substitution (e.g., 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 substitutions), insertion, or deletion or is substantially identical to an amino acid sequence described herein. The peptide or polypeptide may contain, for example, 1 to 12, 1 to 10, 1 to 5, or 1 to 3 amino acid substitutions, for example, 1 to 10 (e.g., to 9, 8, 7, 6, 5, 4, 3, 2) amino acid substitutions. The amino acid substitution(s) may be conservative or non-conservative. For example, the peptide vector may have an arginine at one, two, or three of the positions corresponding to positions 1, 10, and 15 of the amino acid sequence of any of SEQ ID NO:1, Angiopep-1, Angiopep-2, Angiopep-3, Angiopep-4a, Angiopep-4b, Angiopep-5, Angiopep-6, and Angiopep-7. In certain embodiments, the polypeptide therapeutic may have a cysteine or lysine substitution or addition at any position (e.g., a lysine substitution at the N- or C-terminal position).

In any of the above aspects, the compound may specifically exclude a polypeptide including or consisting of any of SEQ ID NOS:1-105 and 107-116 (e.g., Angiopep-1, Angiopep-2, Angiopep-3, Angiopep-4a, Angiopep-4b, Angiopep-5, Angiopep-6, and Angiopep-7). In some embodiments, the polypeptides and conjugates of the invention exclude the polypeptides of SEQ ID NOs:102, 103, 104, and 105.

In any of the above aspects, the linker (X) may be any linker known in the art or described herein. In particular embodiments, the linker is a covalent bond (e.g., a peptide bond), a chemical linking agent (e.g., those described herein), an amino acid or a peptide (e.g., 2, 3, 4, 5, 8, 10, or more amino acids). In certain embodiments, the linker has the formula:



where n is an integer between 2 and 15 (e.g., 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, or 15); and either Y is a thiol on A and Z is a primary amine on B or Y is a thiol on B and Z is a primary amino on A.

By "peptide vector" is meant a compound or molecule such as a polypeptide or a polypeptide mimetic that can be transported into a particular cell type (e.g., liver, lungs, kidney, spleen, or muscle) or across the BBB. The vector may be attached to (covalently or not) or conjugated to an agent and thereby may be able to transport the agent into a particular cell type or across the BBB. In certain embodiments, the vector may bind to receptors present on cancer cells or brain endothelial cells and thereby be transported into the cancer cell or across the BBB by transcytosis. The vector may be a molecule for which high levels of transendothelial transport may be obtained, without affecting the cell or BBB integrity. The vector may be a polypeptide or a peptidomimetic and may be naturally occurring or produced by chemical synthesis or recombinant genetic technology.

By "neurotensin receptor agonist" is meant a compound (e.g., a polypeptide) capable of activating at least one neurotensin receptor as compared to a control compound. Neurotensin receptor activities include production of inositol phosphate.

By "substantially identical" is meant a polypeptide or nucleic acid exhibiting at least 35%, 40%, 50%, 55%, 60%, 65%, 70%, 75%, 85%, 90%, 95%, or even 99% identity to a reference amino acid or nucleic acid sequence. For polypeptides, the length of comparison sequences will generally be at least 4 (e.g., at least 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 50, or 100) amino acids. For nucleic acids, the length of comparison sequences will generally be at least 60 nucleotides, preferably at least 90 nucleotides, and more preferably at least 120 nucleotides, or full length. It is to be understood herein that gaps may be found between the amino acids of an analogs that are identical or similar to amino acids of the original polypeptide. The gaps may include no amino acids, one or more amino acids that are not identical or similar to the original polypeptide. Biologically active analogs of the vectors (polypeptides) of the invention are encompassed herewith. Percent identity may be

determined, for example, with n algorithm GAP, BESTFIT, or FASTA in the Wisconsin Genetics Software Package Release 7.0, using default gap weights.

By "treating" a disease, disorder, or condition in a subject is meant reducing at least one symptom of the disease, disorder, or condition by administrating a therapeutic agent to the subject.

By "treating prophylactically" a disease, disorder, or condition in a subject is meant reducing the frequency of occurrence or severity of (e.g., preventing) a disease, disorder or condition by administering to the subject a therapeutic agent to the subject prior to the appearance of a disease symptom or symptoms.

In one example, a subject who is being treated for a particular condition is one who a medical practitioner has diagnosed as having that condition. Diagnosis may be performed by any suitable means, such as those described herein. A subject in whom the development of the condition is being treated prophylactically may or may not have received such a diagnosis. One in the art will understand that subject of the invention may have been subjected to standard tests or may have been identified, without examination, as one at high risk due to the presence of one or more risk factors.

By "a metabolic disorder" is meant any pathological condition resulting from an alteration in a subject's metabolism. Such disorders include those resulting from an alteration in glucose homeostasis resulting, for example, in hyperglycemia. According to this invention, an alteration in glucose levels is typically an increase in glucose levels by at least 5%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or even 100% relative to such levels in a healthy individual. Metabolic disorders include obesity and diabetes (e.g., diabetes type I, diabetes type II, MODY, and gestational diabetes), satiety, and endocrine deficiencies of aging.

By "subject" is meant a human or non-human animal (e.g., a mammal).

By "equivalent dosage" is meant the amount of a compound of the invention required to achieve the same molar amount of the peptide therapeutic in the compound of the invention, as compared to the unconjugated polypeptide therapeutic. For example, the equivalent dosage of 1.0 μg neurotensin is about 2.5 μg of the neurotensin/Angiopep-2-Cys-NH_2 conjugate described herein.

By a polypeptide which is "efficiently transported across the BBB" is meant a polypeptide that is able to cross the BBB at least as efficiently as Angiopep-6 (i.e.,

greater than 38.5% that of Angiopep-1 (250 nM) in the *in situ* brain perfusion assay described in U.S. Patent Application No. 11/807,597, filed May 29, 2007, hereby incorporated by reference). Accordingly, a polypeptide which is "not efficiently transported across the BBB" is transported to the brain at lower levels (e.g., transported less efficiently than Angiopep-6).

By a polypeptide or compound which is "efficiently transported to a particular cell type" is meant that the polypeptide or compound is able to accumulate (e.g., either due to increased transport into the cell, decreased efflux from the cell, or a combination thereof) in that cell type to at least a 10% (e.g., 25%, 50%, 100%, 200%, 500%, 1,000%, 5,000%, or 10,000%) greater extent than either a control substance, or, in the case of a conjugate, as compared to the unconjugated agent. Such activities are described in detail in International Application Publication No. WO 2007/009229, hereby incorporated by reference.

Other features and advantages of the invention will be apparent from the following Detailed Description, the drawings, and the claims.

Brief Description of the Drawings

Figures 1A and **1B** are chromatograms showing the ECMS-Neurotensin compound (ECMS-NT) before (Figure 1A) and after (Figure 1B) purification using the analytical method described in the examples.

Figure 2 is a chromatogram showing purification of ECMS-NT on an AKTA-explorer with column filled with 30 ml of 30RPC resin.

Figures 3A and **3B** are chromatograms showing a neurotensin-Angiopep-2-Cys amide conjugate (NT-AN2Cys-NH_2 or NT-An2) before (Figure 3A) and after (Figure 3B) purification. These chromatograms were generated using the analytical method described in the examples.

Figure 4 is a chromatogram showing purification of NT-An2 on an AKTA-explorer with column filled with 30 ml of 30RPC resin.

Figure 5 is a graph showing hypothermia induction by NT-An2. Mice received saline (control), NT (1 mg/kg) or NT-An2 at 2.5 mg/kg or 5.0 mg/kg (equivalent to 1 and 2 mg/kg doses of NT). Rectal temperature was monitored 90 minutes following intravenous injection.

Figure 6 is a graph showing the effect of body temperature in mice upon administration of 5, 15, or 20 mg/kg of NT-An2.

Figure 7 is a graph showing the effect of body temperature in mice upon administration of 5, 10, or 20 mg/kg of a different preparation of NT-An2.

Figure 8 is a graph showing in situ brain perfusion of NT and NT-An2. Following iodination, mice brains were perfused in the carotid artery with either [^{125}I]-NT or the [^{125}I]-NT-An2 derivative in Krebs buffer for the indicated times. After the indicated times, brains were further perfused for 30 sec to washout the excess of both compound. Both [^{125}I]-NT or [^{125}I]-NT-An2 derivative in brain were quantified using a beta counter. Results are expressed in terms of brain volume of distribution (ml/100 g) as a function of time.

Figure 9 is a graph showing brain compartmentation of NT and NT-An2 after in situ brain perfusion as described for Figure 6. Brain capillary depletion was performed using Dextran following standard procedures. Both [^{125}I]-NT or [^{125}I]-NT-An2 derivative present in brain, capillaries, and parenchyma were quantified and volume of distribution (ml/100 g/2 min) is reported.

Figure 10 is a graph showing body temperature of mice receiving a bolus 5 mg/kg injection of the NT-An2, followed one hour later by a 2.5 hour infusion of NT-An2 at a rate of 5 mg/kg/30 min (i.e., 10 mg/kg/hr).

Figure 11 is a graph showing body temperature of a rat receiving an intravenous bolus injection of 20 mg/kg NT-An2, followed immediately by a 20 mg/kg/hr infusion of NT-An2 for 3.5 hours.

Figure 12 is a graph showing body temperature of mice receiving an intravenous bolus injection of 20 mg/kg NT-An2, followed immediately by a 20 mg/kg/hr infusion of NT-An2, which was increased to 40 mg/kg/hr after 2.5 hours.

Figure 13 is a graph showing body temperature of rats receiving an intravenous bolus injection of 20 mg/kg NT-An2, followed immediately by a 20 mg/kg/hr infusion of NT-An2.

Figure 14 is a graph showing body temperature of ratings receiving an intravenous bolus injection of 40 mg/kg NT-An2, followed immediately by a 40 mg/kg/hr infusion of NT-An2. This resulted in sustained reduction in body temperature for the 12 hour duration of the experiment.

Figure 15 is a graph showing latency in the hot plate test in mice of the paw licking response in control mice (left), mice receiving 20 mg/kg NT-An2 (center), and mice receiving 1 mg/kg buprenorphine (right) just prior to and 15 minutes following administration of the compound.

Figure 16 is a graph showing body temperature of mice receiving a bolus intravenous 7.5 mg/kg injection of NT(8-13), Ac-Lys-NT(8-13), Ac-Lys-[D-Tyr^{11}]NT(8-13), pGlu-NT(8-13), or a control. From among these analogs, Ac-Lys-[D-Tyr^{11}]NT(8-13) was observed to produce the greatest reduction in body temperature.

Figure 17 is a graph showing body temperature of mice receiving a bolus intravenous injection of a control, NT, NT-An2, NT(8-13)-An2, and Ac-Lys-[D-Tyr^{11}]NT(8-13)-An2. The greatest reduction in body temperature was observed for NT-An2 and Ac-Lys-[D-Tyr^{11}]NT(8-13)-An2 conjugates.

Figure 18 is a graph showing body temperature of mice receiving a bolus intravenous injection of Ac-Lys-[D-Tyr^{11}]NT(8-13) (1 mg/kg) or Ac-Lys-[D-Tyr^{11}]NT(8-13)-An2 (6.25 mg/kg). The An2 conjugated molecule was observed to reduce body temperature to a greater extent that the unconjugated molecule.

Figure 19 is a graph showing body temperature of a mouse receiving a 6.25 mg/kg bolus intravenous injection of the Ac-Lys-[D-Tyr^{11}]NT(8-13)-An2 conjugate followed 60 minutes later by a 6.25 mg/kg/hr infusion of the conjugate.

Figure 20 is a graph showing binding of radiolabeled NT ([^{3}H]-NT) to HT29 cells that express the NTSR1 in the presence or absence of 40 nM of NT at 4 °C or 37 °C.

Figure 21 is a graph showing binding of [^{3}H]-NT to HT29 cells in the presence of NT at concentrations ranging from 0.4 nM to 40 nM.

Figure 22 is graph showing binding of [^{3}H]-NT to HT29 cells in the presence of NT or Ac-Lys-[D-Tyr^{11}]NT(8-13).

Detailed Description

We have developed neurotensin conjugates having an enhanced ability to cross the blood-brain barrier (BBB) or to enter particular cell type(s) (e.g., liver, lung, kidney, spleen, and muscle). Surprisingly, we have shown that the compounds of the invention, as compared to unconjugated neurotensin peptide, are far more effective in

causing a neurotensin response, such as a reduction in body temperature, as compared to unconjugated neurotensin. Because the compounds of the invention exhibit higher response, lower doses of the conjugated peptides can be effectively, and may be used to reduce or eliminate side effects. Alternatively, the observed increased efficacy can result in a greater therapeutic effect using higher doses. Indeed, these compounds, unlike certain prior hypothermic techniques, are capable of rapidly inducing a sustainable hypothermic response (e.g., over a period of at least 3, 4, 5, 6, 8, 10, 12, 15, 18, 21, 24, 30, 36, or 48 hours) without inducing shivering.

Neurotensin

Neurotensin (NT) is a 13 amino acid peptide found in the central nervous system and in the gastrointestinal tract. In brain, NT is associated with dopaminergic receptors and other neurotransmitter system. Peripheral NT acts as a paracrine and endocrine peptide on both the digestive and cardiovascular systems. To exert its biological effects in the brain NT has to be injected or delivered directly to the brain because NT does not cross the BBB and is rapidly degraded by peptidases following systematic administration. Preclinical pharmacological studies, most of which involve direct injection of NT into the brain, strongly suggest that an agonist of NT receptors would be clinically useful for the treatment of neuropsychiatric conditions including psychosis, schizophrenia, Parkinson's disease, pain, and the abuse of psychostimulants. In particular, in various animal studies, intraventricular injection of NT led to hypothermia and analgesia in antinociception experiments.

The peptide therapeutic may be neurotensin or analog thereof. Human neurotensin is a thirteen amino acid peptide having the sequence QLYENKPRRPYIL. Exemplary neurotensin analogs include (VIP-neurotensin) hybrid antagonist, acetylneurotensin(8-13), JMV 1193, KK13 peptide, neuromedin N, neuromedin N precursor, neurotensin(1-10), neurotensin(1-11), neurotensin(1-13), neurotensin(1-6), neurotensin(1-8), neurotensin(8-13), Asp(12)-neurotensin(8-13), Asp(13)-neurotensin(8-13), Lys(8)-neurotensin(8-13), N-methyl-Arg(8)-Lys(9)-neo-Trp(11)-neo-Leu(12)-neurotensin(8-13), neurotensin(9-13), neurotensin 69L, Arg(9)-neurotensin, azidobenzoyl-Lys(6)-Trp(11)-neurotensin, Gln(4)-neurotensin, iodo-Tyr(11)-neurotensin, iodo-Tyr(3)-neurotensin, N-α-(fluoresceinylthiocarbamyl)glutamyl(1)-neurotensin, Phe(11)-neurotensin, Ser(7)-

neurotensin, Trp(11)-neurotensin, Tyr(11)-neurotensin, rat NT77, PD 149163, proneurotensin, stearyl-Nle(17)-neurotensin(6-11)VIP(7-28), ^{99m}Tc-NT-XI, TJN 950, and vasoactive intestinal peptide-neurotensin hybrid.

Other neurotensin analogs include NT64L [L-neo-Trp11]NT(8-13), NT72D [D-Lys9,D-neo-Trp11,tert-Leu12]NT(9-13), NT64D [D-neo-Trp11]NT(8-13), NT73L [D-Lys9,L-neo-Trp11]NT(9-13), NT65L [L-neo-Trp11, tert-Leu12]NT(8-13), NT73D [D-Lys9,D-neo-Trp11]NT(9-13), NT65D [D-neo-Trp11, tert-Leu12]NT(8-13), NT74L [DAB9,L-neo-Trp11,tert-Leu12]NT(9-13), NT66L [D-Lys8, L-neo-Trp11, tert-Leu12]NT(8-13), NT74D [DAB9,Pro,D-neo-Trp11,tert-Leu12]NT(9-13), NT66D [D-Lys8, D-neo-Trp11, tert-Leu12]NT(8-13), NT75L [DAB8 L-neo-Trp11]NT(8-13), NT67L [D-Lys8, L-neo-Trp11]NT(8-13), NT75D [DAB8,D-neo-Trp11]NT(8-13), NT67D [D-Lys8, D-neo-Trp11]NT(8-13), NT76L [D-Orn9,L-neo-Trp11]NT(8-13), NT69L [N-methyl-Arg8,L-Lys9 L-neo-Trp11,tert-Leu12]NT(8-13), NT76D [D-Orn9,D-neo-Trp11]NT(8-13), NT69D [N-methyl-Arg8 L-Lys9,D-neo-Trp11,tert-Leu12]NT(8-13), NT77L [D-Orn9,L-neo-Trp11,tert-Leu12]NT(8-13), NT71L [N-methyl-Arg8,DAB9 L-neo-Trp11,tert-leu12]NT(8-13), NT77D [D-Orn9,D-neo-Trp11,tert-Leu12]NT(8-13), NT71D [N-methyl-Arg8,DAB9,D-neo-Trp11,tert-leu12]NT(8-13), NT78L [N-methyl-Arg8,D-Orn9 L-neo-Trp11,tert-Leu12]NT(8-13), NT72L [D-Lys9,L-neo-Trp11,tert-Leu12]NT(9-13), and NT78D [N-methyl-Arg8,D-Orn9,D-neo-Trp11,tert-Leu12]NT(8-13), where neo-Trp is (2-amino-3-[1H-indolyl]propanoic acid). Other neurotensin analogs include Beta-lactotensin (NTR2 selective), JMV-449, and PD-149 or PD-163 (NTR1 selective; reduced amide bond 8-13 fragment of neurotensin).

Still other NT analogs include guinea pig NT, [Gln^{4}]NT, [D-Trp^{11}]NT, NT(9-13), frog NT, [Gln^{4}]NT, [D-Phe^{11}]NT, [D-Trp^{11}]NT, [D-Tyr^{11}]NT, Ac-NT(8-13), [Lys^{8,9}]NT(8-13), [3,5-diBr-Tyr^{11}]NT, Nα-Acetyl-NT(8-13), Nα,Nε-di-Boc-[Lys^{9}]NT(9-13) methyl ester, Boc-[Lys^{9}]NT(9-13)-methyl ester, [Trp^{11}]NT, [Dab^{9}]NT (8-13), [Lys^{9},Trp^{11},Glu^{12}]NT(8-13) (Cyclo(-Arg-Lys-Pro-Trp-Glu)-Leu-OH), [Lys^{8}-(®)-Lys^{9}]NT(8-13) (where ® is a CH_2NH replacement of the peptide bond), DTPA-DLys-Pro-Gly(PipAm)-Arg-(4-oxo)Pro-Tyr-tBuGly-Leu-OH, DTPA-DLys-Pro-Gly(PipAm)-Arg-Pro-(2,6diMe)Tyr-tBuGly-Leu-OH, DTPA-DLys-Pro-Gly(PipAm)-Arg-Pro-mTyr-tBuGly-Leu-OH, wherein mTyr stands for metatyrosine such that the -OH group of the Tyr is in the meta position, DTPA-DLys-Pro-

Gly(PipAm)-PipGly-Pro-Tyr-tBuGly-Leu-OH, DTPA-DLys-Pro-Gly(PipAm)-Arg-AzeCA-Tyr-tBuGly-Leu-OH, DTPA-DLys-AzeCA-Gly(PipAm)-Arg-Pro-Tyr-tBuGly-Leu-OH, DTPA-DLys-Pro-Gly(PipAm)-Arg-Pro-Tyr-Achc-Leu-OH, DTPA-DLys-Pro-Gly(PipAm)-Arg-Pro-Tyr-tBuGly-Cpa-OH, DTPA-DLys-Pro-Gly(PipAm)-Arg-Pro-Tyr-tBuGly-Cha-OH, DTPA-DLys-Pro-Gly(PipAm)-Arg-Pro-Tyr-tBuGly-tBuAla-OH, DTPA-DLys-Pro-Gly(PipAm)-Arg-PipCA-Tyr-tBuGly-Leu-OH, DTPA-DLys-Pro-Gly(PipAm)-Arg-DPipCA-Tyr-tBuGly-Leu-OH, DTPA-DLys-Pro-Gly(PipAm)-Arg-Pro-Tyr-Chg-Leu-OH, DTPA-DLys-Pro-Gly(PipAm)-Arg-Pro-DTyr-tBuGly-Leu-OH, and those described in U.S. Patent Application Publication 2009/0062212: D-Lys L-Arg L-Pro L-Tyr L-Ile L-Leu, L-Arg D-Lys L-Pro L-Tyr L-Ile L-Leu, L-Arg D-Arg L-Pro L-Tyr L-Ile L-Leu, L-Arg L-Arg L-Pro L-Tyr L-Ile D-Leu, L-Arg L-Arg Gly L-Tyr L-Ile L-Leu, L-Arg L-Arg L-Pro L-Ala L-Ile L-Leu, L-Arg L-Arg L-Pro L-Tyr L-Leu L-Leu, L-Arg L-Arg L-Pro L-Tyr L-Val L-Leu, D-Arg L-Arg L-Pro L-Tyr L-Ile L-Leu, D-Arg D-Arg L-Pro L-Tyr L-Ile L-Leu, D-Arg L-Lys L-Pro L-Tyr L-Ile L-Leu, L-Lys D-Arg L-Pro L-Tyr L-Ile L-Leu, L-Lys L-Arg L-Pro L-Tyr L-Ile L-Leu, L-Arg L-Lys L-Pro L-Tyr L-Ile L-Leu, L-Lys L-Lys L-Pro L-Tyr L-Ile L-Leu, D-Lys D-Lys L-Pro L-Tyr L-Ile L-Leu, L-Orn L-Arg L-Pro L-Tyr L-Ile L-Leu, D-Orn L-Arg L-Pro L-Tyr L-Ile L-Leu, L-Arg L-Orn L-Pro L-Tyr L-Ile L-Leu, L-Arg D-Orn L-Pro L-Tyr L-Ile L-Leu, L-Orn L-Orn L-Pro L-Tyr L-Ile L-Leu, L-Orn D-Orn L-Pro L-Tyr L-Ile L-Leu, D-Orn L-Orn L-Pro L-Tyr L-Ile L-Leu, D-Orn D-Orn L-Pro L-Tyr L-Ile L-Leu, DAB L-Arg L-Pro L-Tyr L-Ile L-Leu, L-Arg DAB L-Pro L-Tyr L-Ile L-Leu, DAB DAB L-Pro L-Tyr L-Ile L-Leu, L-Arg L-Arg L-Pro CHA L-Ile L-Leu, L-Arg L-Arg L-Pro L-3,2-Nal-L-Ile L-Leu, L-Orn L-Pro L-Tyr L-Ile L-Leu, D-Orn L-Pro L-Tyr L-Ile L-Leu, L-Arg L-Orn L-Pro D-Tyr L-Ile L-Leu, L-Arg D-Orn L-Pro D-Tyr L-Ile L-Leu, DAP L-Arg L-Pro L-Tyr L-Ile L-Leu, L-Arg DAP L-Pro L-Tyr L-Ile L-Leu, DAP DAP L-Pro L-Tyr L-Ile L-Leu, L-Arg L-homoArg L-Pro L-Tyr L-Ile L-Leu, L-homoArg L-homoArg L-Pro L-Tyr L-Ile L-Leu, L-homoArg L-Arg L-Pro L-Tyr L-Ile L-Leu, L-Arg L-Arg L-Pro L-TIC L-Ile L-Leu, L-Arg L-Arg L-Pro D-TIC L-Ile L-Leu, L-Arg L-Arg L-Pro L-3,1-Nal L-Ile L-Leu, L-Arg L-Arg L-Pro D-3,1-Nal L-Ile L-Leu, L-Arg L-Arg L-Pro D-3,2-Nal L-Ile L-Leu, L-Arg L-Arg L-Pip L-Tyr L-Ile L-Leu, p-Glu L-Leu L-Tyr L-Glu L-Asn L-Lys L-Pro BPA L-Arg L-Pro L-Tyr L-Ile L-Leu, p-Glu L-Leu L-Tyr L-Glu BPA L-Lys L-Pro L-Arg L-Arg L-Pro L-Tyr L-Ile L-Leu, p-Glu L-Leu L-Tyr L-

Glu L-Asn L-Lys L-Pro L-Arg BPA L-Pro L-Tyr L-Ile L-Leu, L-Arg DAB L-Pro L-3,1-Nal L-Ile L-Leu, p-Glu L-Leu L-Tyr L-Glu L-Asn L-Lys L-Pro L-Arg L-Orn L-Pro L-Tyr L-Ile L-Leu, p-Glu L-Leu L-Tyr L-Glu L-Asn L-Lys L-Pro L-Arg D-Orn L-Pro L-Tyr L-Ile L-Leu, p-Glu L-Leu L-Tyr L-Glu L-Asn L-Lys L-Pro L-Arg L-Arg L-Pro L-3,1-Nal L-Ile L-Leu, L-Arg L-Arg L-Pro L-neo-Trp L-Ile L-Leu, L-Arg L-Arg L-Pro L-neo-Trp tert-Leu L-Leu, D-Lys L-Arg L-Pro L-neo-Trp tert-Leu L-Leu, D-Lys L-Arg L-Pro L-Trp tert-Leu L-Leu, D-Lys L-Arg L-Pro L-neo-Trp L-Ile L-Leu, D-Lys L-Arg L-Pro L-Trp L-Ile L-Leu, N- methyl-Arg L-Lys L-Pro L-neo-Trp tert-Leu L-Leu, p-Glu L-Leu L-iodo-Tyr L-Glu L-Asn L-Lys L-Pro L-Arg L-Arg L-Pro L-Tyr L-Ile L-Leu, N-methyl-Arg DAB L-Pro L-neo-Trp tert-Leu L-Leu, D-Lys L-Pro L-neo-Trp tert-Leu L-Leu, D-Lys L-Pro L-neo-Trp L-Ile L-Leu, DAB L-Arg L-Pro L-neo-Trp L-Ile L-Leu, L-Arg D-Orn L-Pro L-neo-Trp tert-Leu L-Leu, L-Arg D-Orn L-Pro L-Trp tert-Leu L-Leu, N-methyl-Arg D-Orn L-Pro L-neo-Trp tert-Leu L-Leu, N-methyl-Arg D-Orn L-Pro L-Trp tert-Leu L-Leu, N-methyl Arg L-Arg L-Pro D-3,1-Nal tert-Leu L-Leu, and N-methyl-Arg L-Arg L-Pro D-3,1-Nal L-Ile L-Leu. Abbreviations: BPA = benzoylphenylalanine; CHA = cyclohexylalanine; DAB = diaminobutyric acid; DAP = diaminoproprionic acid; homoArg = homoarginine; Orn = ornithine; Nal = naphthyl-alanine; Pip = 1-pipecolinic acid; neo-Trp = a regio-isomer of the native tryptophan (Fauq et al., Tetrahedron: Asymmetry 9:4127-34 (1998)); TIC = 1,2,3,4-tetrahydroisoquinoline-3-carboxylic acid)

Other neurotensin analogs include those with modified amino acids (e.g., any of those described herein). The neurotensin analog may be selective for NTR1, NTR2, or NTR3 (e.g., may bind to or activate one of NTR1, NTR2, or NTR3 at least 2, 5, 10, 50, 100, 500, 1000, 5000, 10,000, 50,000, or 100,000 greater) as compared to at least one of the other NTR receptors or both.

Modified forms of polypeptide therapeutics

Any of the polypeptide therapeutics described herein (e.g., neurotensin, a neurotensin analog, or neurotensin receptor agonist) may be modified (e.g., as described herein or as known in the art). As described in U.S. Patent No. 6,924,264, the polypeptide can be bound to a polymer to increase its molecular weight. Exemplary polymers include polyethylene glycol polymers, polyamino acids,

albumin, gelatin, succinyl-gelatin, (hydroxypropyl)-methacrylamide, fatty acids, polysaccharides, lipid amino acids, and dextran.

In one case, the polypeptide is modified by addition of albumin (e.g., human albumin), or an analog or fragment thereof, or the Fc portion of an immunoglobulin. Such an approach is described, for example, in U.S. Patent No. 7,271,149.

In one example, the polypeptide is modified by addition of a lipophilic substituent, as described in PCT Publication WO 98/08871. The lipophilic substituent may include a partially or completely hydrogenated cyclopentanophenathrene skeleton, a straight-chain or branched alkyl group; the acyl group of a straight-chain or branched fatty acid (e.g., a group including $CH_3(CH_2)_nCO$- or $HOOC(CH_2)_mCO$-, where n or m is 4 to 38); an acyl group of a straight-chain or branched alkane α,ω-dicarboxylic acid; $CH_3(CH_2)_p((CH_2)_q,COOH)CHNH$-$CO(CH_2)_2CO$-, where p and q are integers and p+q is 8 to 33; $CH_3(CH_2)_rCO$-$NHCH(COOH)(CH_2)_2CO$-, where r is 10 to 24; $CH_3(CH_2)_sCO$-$NHCH((CH_2)_2COOH)CO$-, where s is 8 to 24; $COOH(CH_2)_tCO$-, where t is 8 to 24; -$NHCH(COOH)(CH_2)_4NH$-$CO(CH_2)_uCH_3$, where u is 8 to 18; -$NHCH(COOH)(CH_2)_4NH$-$COCH((CH_2)_2COOH)NH$-$CO(CH_2)_wCH_3$, where w is 10 to 16; -$NHCH(COOH)(CH_2)_4NH$-$CO(CH_2)_2CH(COOH)NH$-$CO(CH_2)_xCH_3$, where x is 10 to 16; or -$NHCH(COOH)(CH_2)_4NH$-$CO(CH_2)_2CH(COOH)NHCO(CH_2)_yCH_3$, where y is 1 to 22.

In other embodiments, the polypeptide therapeutic is modified by addition of a chemically reactive group such as a maleimide group, as described in U.S. Patent No. 6,593,295. These groups can react with available reactive functionalities on blood components to form covalent bonds and can extending the effective therapeutic in vivo half-life of the modified polypeptides. To form covalent bonds with the functional group on a protein, one can use as a chemically reactive group a wide variety of active carboxyl groups (e.g., esters) where the hydroxyl moiety is physiologically acceptable at the levels required to modify the peptide. Particular agents include N-hydroxysuccinimide (NHS), N-hydroxy-sulfosuccinimide (sulfo-NHS), maleimide-benzoyl-succinimide (MBS), gamma-maleimido-butyryloxy succinimide ester (GMBS), maleimido propionic acid (MPA) maleimido hexanoic acid (MHA), and maleimido undecanoic acid (MUA).

Primary amines are the principal targets for NHS esters. Accessible α-amine groups present on the N-termini of proteins and the ε-amine of lysine react with NHS esters. An amide bond is formed when the NHS ester conjugation reaction reacts with primary amines releasing N-hydroxysuccinimide. These succinimide containing reactive groups are herein referred to as succinimidyl groups. In certain embodiments of the invention, the functional group on the protein will be a thiol group and the chemically reactive group will be a maleimido-containing group such as gamma-maleimide-butrylamide (GMBA or MPA). Such maleimide containing groups are referred to herein as maleido groups.

The maleimido group is most selective for sulfhydryl groups on peptides when the pH of the reaction mixture is 6.5-7.4. At pH 7.0, the rate of reaction of maleimido groups with sulfhydryls (e.g., thiol groups on proteins such as serum albumin or IgG) is 1000-fold faster than with amines. Thus, a stable thioether linkage between the maleimido group and the sulfhydryl is formed, which cannot be cleaved under physiological conditions.

Peptide vectors

The compounds of the invention can feature any of polypeptides described herein, for example, any of the peptides described in Table 1 (e.g., Angiopep-1 or Angiopep-2), or a fragment or analog thereof. In certain embodiments, the polypeptide may have at least 35%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 99%, or even 100% identity to a polypeptide described herein. The polypeptide may have one or more (e.g., 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, or 15) substitutions relative to one of the sequences described herein. Other modifications are described in greater detail below.

The invention also features fragments of these polypeptides (e.g., a functional fragment). In certain embodiments, the fragments are capable of efficiently being transported to or accumulating in a particular cell type (e.g., liver, eye, lung, kidney, or spleen) or are efficiently transported across the BBB. Truncations of the polypeptide may be 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, or more amino acids from either the N-terminus of the polypeptide, the C-terminus of the polypeptide, or a combination thereof. Other fragments include sequences where internal portions of the polypeptide are deleted.

Additional polypeptides may be identified by using one of the assays or methods described herein. For example, a candidate polypeptide may be produced by conventional peptide synthesis, conjugated with paclitaxel and administered to a laboratory animal. A biologically-active polypeptide conjugate may be identified, for example, based on its ability to increase survival of an animal injected with tumor cells and treated with the conjugate as compared to a control which has not been treated with a conjugate (e.g., treated with the unconjugated agent). For example, a biologically active polypeptide may be identified based on its location in the parenchyma in an *in situ* cerebral perfusion assay.

Assays to determine accumulation in other tissues may be performed as well. Labeled conjugates of a polypeptide can be administered to an animal, and accumulation in different organs can be measured. For example, a polypeptide conjugated to a detectable label (e.g., a near-IR fluorescence spectroscopy label such as Cy5.5) allows live in vivo visualization. Such a polypeptide can be administered to an animal, and the presence of the polypeptide in an organ can be detected, thus allowing determination of the rate and amount of accumulation of the polypeptide in the desired organ. In other embodiments, the polypeptide can be labelled with a radioactive isotope (e.g., ^{125}I). The polypeptide is then administered to an animal. After a period of time, the animal is sacrificed and the organs are extracted. The amount of radioisotope in each organ can then be measured using any means known in the art. By comparing the amount of a labeled candidate polypeptide in a particular organ relative to the amount of a labeled control polypeptide, the ability of the candidate polypeptide to access and accumulate in a particular tissue can be ascertained. Appropriate negative controls include any peptide or polypeptide known not to be efficiently transported into a particular cell type (e.g., a peptide related to Angiopep that does not cross the BBB, or any other peptide).

Additional sequences are described in U.S. Patent No. 5,807,980 (e.g., SEQ ID NO:102 herein), 5,780,265 (e.g., SEQ ID NO:103), 5,118,668 (e.g., SEQ ID NO:105). An exemplary nucleotide sequence encoding an aprotinin analog atgagaccag atttctgcct cgagccgccg tacactgggc cctgcaaagc tcgtatcatc cgttacttct acaatgcaaa ggcaggcctg tgtcagacct tcgtatacgg cggctgcaga gctaagcgta acaacttcaa atccgcggaa gactgcatgc gtacttgcgg tggtgcttag; SEQ ID NO:6; Genbank accession No. X04666). Other examples of aprotinin analogs may be found by performing a protein

BLAST (Genbank: www.ncbi.nlm.nih.gov/BLAST/) using the synthetic aprotinin sequence (or portion thereof) disclosed in International Application No. PCT/CA2004/000011. Exemplary aprotinin analogs are also found under accession Nos. CAA37967 (GI:58005) and 1405218C (GI:3604747).

Modified polypeptides

The peptide vectors and polypeptide therapeutics used in the invention may have a modified amino acid sequence. In certain embodiments, the modification does not destroy significantly a desired biological activity (e.g., ability to cross the BBB or neurotensin agonist activity). The modification may reduce (e.g., by at least 5%, 10%, 20%, 25%, 35%, 50%, 60%, 70%, 75%, 80%, 90%, or 95%), may have no effect, or may increase (e.g., by at least 5%, 10%, 25%, 50%, 100%, 200%, 500%, or 1000%) the biological activity of the original polypeptide. The modified peptide or polypeptide may have or may optimize a characteristic of a polypeptide, such as in vivo stability, bioavailability, toxicity, immunological activity, immunological identity, and conjugation properties.

Modifications include those by natural processes, such as posttranslational processing, or by chemical modification techniques known in the art. Modifications may occur anywhere in a polypeptide including the polypeptide backbone, the amino acid side chains and the amino- or carboxy-terminus. The same type of modification may be present in the same or varying degrees at several sites in a given polypeptide, and a polypeptide may contain more than one type of modification. Polypeptides may be branched as a result of ubiquitination, and they may be cyclic, with or without branching. Cyclic, branched, and branched cyclic polypeptides may result from posttranslational natural processes or may be made synthetically. Other modifications include pegylation, acetylation, acylation, addition of acetomidomethyl (Acm) group, ADP-ribosylation, alkylation, amidation, biotinylation, carbamoylation, carboxyethylation, esterification, covalent attachment to fiavin, covalent attachment to a heme moiety, covalent attachment of a nucleotide or nucleotide derivative, covalent attachment of drug, covalent attachment of a marker (e.g., fluorescent or radioactive), covalent attachment of a lipid or lipid derivative, covalent attachment of phosphatidylinositol, cross-linking, cyclization, disulfide bond formation, demethylation, formation of covalent crosslinks, formation of cystine, formation of

pyroglutamate, formylation, gamma-carboxylation, glycosylation, GPI anchor formation, hydroxylation, iodination, methylation, myristoylation, oxidation, proteolytic processing, phosphorylation, prenylation, racemization, selenoylation, sulfation, transfer-RNA mediated addition of amino acids to proteins such as arginylation and ubiquitination.

A modified polypeptide can also include an amino acid insertion, deletion, or substitution, either conservative or non-conservative (e.g., D-amino acids, desamino acids) in the polypeptide sequence (e.g., where such changes do not substantially alter the biological activity of the polypeptide). In particular, the addition of one or more cysteine residues to the amino or carboxy terminus of any of the polypeptides of the invention can facilitate conjugation of these polypeptides by, e.g., disulfide bonding. For example, Angiopep-1 (SEQ ID NO:67), Angiopep-2 (SEQ ID NO:97), or Angiopep-7 (SEQ ID NO:112) can be modified to include a single cysteine residue at the amino-terminus (SEQ ID NOS: 71, 113, and 115, respectively) or a single cysteine residue at the carboxy-terminus (SEQ ID NOS: 72, 114, and 116, respectively). Amino acid substitutions can be conservative (i.e., wherein a residue is replaced by another of the same general type or group) or non-conservative (i.e., wherein a residue is replaced by an amino acid of another type). In addition, a non-naturally occurring amino acid can be substituted for a naturally occurring amino acid (i.e., non-naturally occurring conservative amino acid substitution or a non-naturally occurring non-conservative amino acid substitution).

Polypeptides made synthetically can include substitutions of amino acids not naturally encoded by DNA (e.g., non-naturally occurring or unnatural amino acid). Examples of non-naturally occurring amino acids include D-amino acids, an amino acid having an acetylaminomethyl group attached to a sulfur atom of a cysteine, a pegylated amino acid, the omega amino acids of the formula $NH_2(CH_2)_nCOOH$ wherein n is 2-6, neutral nonpolar amino acids, such as sarcosine, t-butyl alanine, t-butyl glycine, N-methyl isoleucine, and norleucine. Phenylglycine may substitute for Trp, Tyr, or Phe; citrulline and methionine sulfoxide are neutral nonpolar, cysteic acid is acidic, and ornithine is basic. Proline may be substituted with hydroxyproline and retain the conformation conferring properties.

Analogs may be generated by substitutional mutagenesis and retain the biological activity of the original polypeptide. Examples of substitutions identified as

"conservative substitutions" are shown in Table 2. If such substitutions result in a change not desired, then other type of substitutions, denominated "exemplary substitutions" in Table 3, or as further described herein in reference to amino acid classes, are introduced and the products screened.

Substantial modifications in function or immunological identity are accomplished by selecting substitutions that differ significantly in their effect on maintaining (a) the structure of the polypeptide backbone in the area of the substitution, for example, as a sheet or helical conformation. (b) the charge or hydrophobicity of the molecule at the target site, or (c) the bulk of the side chain. Naturally occurring residues are divided into groups based on common side chain properties:

(1) hydrophobic: norleucine, methionine (Met), Alanine (Ala), Valine (Val), Leucine (Leu), Isoleucine (Ile), Histidine (His), Tryptophan (Trp), Tyrosine (Tyr), Phenylalanine (Phe),

(2) neutral hydrophilic: Cysteine (Cys), Serine (Ser), Threonine (Thr)

(3) acidic/negatively charged: Aspartic acid (Asp), Glutamic acid (Glu)

(4) basic: Asparagine (Asn), Glutamine (Gln), Histidine (His), Lysine (Lys), Arginine (Arg)

(5) residues that influence chain orientation: Glycine (Gly), Proline (Pro);

(6) aromatic: Tryptophan (Trp), Tyrosine (Tyr), Phenylalanine (Phe), Histidine (His),

(7) polar: Ser, Thr, Asn, Gln

(8) basic positively charged: Arg, Lys, His, and;

(9) charged: Asp, Glu, Arg, Lys, His

Other amino acid substitutions are listed in Table 3.

Table 2: Amino acid substitutions

Original residue	Exemplary substitution	Conservative substitution
Ala (A)	Val, Leu, Ile	Val
Arg (R)	Lys, Gln, Asn	Lys
Asn (N)	Gln, His, Lys, Arg	Gln
Asp (D)	Glu	Glu
Cys (C)	Ser	Ser
Gln (Q)	Asn	Asn
Glu (E)	Asp	Asp
Gly (G)	Pro	Pro

Original residue	Exemplary substitution	Conservative substitution
His (H)	Asn, Gln, Lys, Arg	Arg
Ile (I)	Leu, Val, Met, Ala, Phe, norleucine	Leu
Leu (L)	Norleucine, Ile, Val, Met, Ala, Phe	Ile
Lys (K)	Arg, Gln, Asn	Arg
Met (M)	Leu, Phe, Ile	Leu
Phe (F)	Leu, Val, Ile, Ala	Leu
Pro (P)	Gly	Gly
Ser (S)	Thr	Thr
Thr (T)	Ser	Ser
Trp (W)	Tyr	Tyr
Tyr (Y)	Trp, Phe, Thr, Ser	Phe
Val (V)	Ile, Leu, Met, Phe, Ala, norleucine	Leu

Polypeptide derivatives and peptidomimetics

In addition to polypeptides consisting of naturally occurring amino acids, peptidomimetics or polypeptide analogs are also encompassed by the present invention and can form the peptide vectors or peptide therapeutics used in the compounds of the invention. Polypeptide analogs are commonly used in the pharmaceutical industry as non-peptide drugs with properties analogous to those of the template polypeptide. The non-peptide compounds are termed "peptide mimetics" or peptidomimetics (Fauchere et al., *Infect. Immun.* 54:283-287,1986 and Evans et al., *J. Med. Chem.* 30:1229-1239, 1987). Peptide mimetics that are structurally related to therapeutically useful peptides or polypeptides may be used to produce an equivalent or enhanced therapeutic or prophylactic effect. Generally, peptidomimetics are structurally similar to the paradigm polypeptide (i.e., a polypeptide that has a biological or pharmacological activity) such as naturally-occurring receptor-binding polypeptides, but have one or more peptide linkages optionally replaced by linkages such as $-CH_2NH-$, $-CH_2S-$, $-CH_2-CH_2-$, $-CH=CH-$ (cis and trans), $-CH_2SO-$, $-CH(OH)CH_2-$, $-COCH_2-$ etc., by methods well known in the art (Spatola, *Peptide Backbone Modifications, Vega Data,* 1:267, 1983; Spatola et al., *Life Sci.* 38:1243-1249, 1986; Hudson et al., *Int. J. Pept. Res.* 14:177-185, 1979; and Weinstein, 1983, Chemistry and Biochemistry, of Amino Acids, Peptides and Proteins, Weinstein eds, Marcel Dekker, New York). Such polypeptide mimetics may have significant advantages over naturally occurring polypeptides including more economical

production, greater chemical stability, enhanced pharmacological properties (e.g., half-life, absorption, potency, efficiency), reduced antigenicity, and others.

While the peptide vectors described herein may efficiently cross the BBB or target particular cell types (e.g., those described herein), their effectiveness may be reduced by the presence of proteases. Likewise, the effectiveness of the polypeptide therapeutics used in the invention may be similarly reduced. Serum proteases have specific substrate requirements, including L-amino acids and peptide bonds for cleavage. Furthermore, exopeptidases, which represent the most prominent component of the protease activity in serum, usually act on the first peptide bond of the polypeptide and require a free N-terminus (Powell et al., *Pharm. Res.* 10:1268-1273, 1993). In light of this, it is often advantageous to use modified versions of polypeptides. The modified polypeptides retain the structural characteristics of the original L-amino acid polypeptides, but advantageously are not readily susceptible to cleavage by protease and/or exopeptidases.

Systematic substitution of one or more amino acids of a consensus sequence with D-amino acid of the same type (e.g., an enantiomer; D-lysine in place of L-lysine) may be used to generate more stable polypeptides. Thus, a polypeptide derivative or peptidomimetic as described herein may be all L-, all D-, or mixed D, L polypeptides. The presence of an N-terminal or C-terminal D-amino acid increases the in vivo stability of a polypeptide because peptidases cannot utilize a D-amino acid as a substrate (Powell et al., *Pharm. Res.* 10:1268-1273, 1993). Reverse-D polypeptides are polypeptides containing D-amino acids, arranged in a reverse sequence relative to a polypeptide containing L-amino acids. Thus, the C-terminal residue of an L-amino acid polypeptide becomes N-terminal for the D-amino acid polypeptide, and so forth. Reverse D-polypeptides retain the same tertiary conformation and therefore the same activity, as the L-amino acid polypeptides, but are more stable to enzymatic degradation in vitro and in vivo, and thus have greater therapeutic efficacy than the original polypeptide (Brady and Dodson, *Nature* 368:692-693, 1994 and Jameson et al., *Nature* 368:744-746, 1994). In addition to reverse-D-polypeptides, constrained polypeptides comprising a consensus sequence or a substantially identical consensus sequence variation may be generated by methods well known in the art (Rizo et al., *Ann. Rev. Biochem.* 61:387-418, 1992). For example, constrained polypeptides may be generated by adding cysteine residues

capable of forming disulfide bridges and, thereby, resulting in a cyclic polypeptide. Cyclic polypeptides have no free N- or C-termini. Accordingly, they are not susceptible to proteolysis by exopeptidases, although they are, of course, susceptible to endopeptidases, which do not cleave at polypeptide termini. The amino acid sequences of the polypeptides with N-terminal or C-terminal D-amino acids and of the cyclic polypeptides are usually identical to the sequences of the polypeptides to which they correspond, except for the presence of N-terminal or C-terminal D-amino acid residue, or their circular structure, respectively.

A cyclic derivative containing an intramolecular disulfide bond may be prepared by conventional solid phase synthesis while incorporating suitable S-protected cysteine or homocysteine residues at the positions selected for cyclization such as the amino and carboxy termini (Sah et al., *J. Pharm. Pharmacol.* 48:197, 1996). Following completion of the chain assembly, cyclization can be performed either (1) by selective removal of the S-protecting group with a consequent on-support oxidation of the corresponding two free SH-functions, to form a S-S bonds, followed by conventional removal of the product from the support and appropriate purification procedure or (2) by removal of the polypeptide from the support along with complete side chain de-protection, followed by oxidation of the free SH-functions in highly dilute aqueous solution.

The cyclic derivative containing an intramolecular amide bond may be prepared by conventional solid phase synthesis while incorporating suitable amino and carboxyl side chain protected amino acid derivatives, at the position selected for cyclization. The cyclic derivatives containing intramolecular -S-alkyl bonds can be prepared by conventional solid phase chemistry while incorporating an amino acid residue with a suitable amino-protected side chain, and a suitable S-protected cysteine or homocysteine residue at the position selected for cyclization.

Another effective approach to confer resistance to peptidases acting on the N-terminal or C-terminal residues of a polypeptide is to add chemical groups at the polypeptide termini, such that the modified polypeptide is no longer a substrate for the peptidase. One such chemical modification is glycosylation of the polypeptides at either or both termini. Certain chemical modifications, in particular N-terminal glycosylation, have been shown to increase the stability of polypeptides in human serum (Powell et al., *Pharm. Res.* 10:1268-1273, 1993). Other chemical

modifications which enhance serum stability include, but are not limited to, the addition of an N-terminal alkyl group, consisting of a lower alkyl of from one to twenty carbons, such as an acetyl group, and/or the addition of a C-terminal amide or substituted amide group. In particular, the present invention includes modified polypeptides consisting of polypeptides bearing an N-terminal acetyl group and/or a C-terminal amide group.

Also included by the present invention are other types of polypeptide derivatives containing additional chemical moieties not normally part of the polypeptide, provided that the derivative retains the desired functional activity of the polypeptide. Examples of such derivatives include (1) N-acyl derivatives of the amino terminal or of another free amino group, wherein the acyl group may be an alkanoyl group (e.g., acetyl, hexanoyl, octanoyl) an aroyl group (e.g., benzoyl) or a blocking group such as F-moc (fluorenylmethyl-O–CO–); (2) esters of the carboxy terminal or of another free carboxy or hydroxyl group; (3) amide of the carboxy-terminal or of another free carboxyl group produced by reaction with ammonia or with a suitable amine; (4) phosphorylated derivatives.

Longer polypeptide sequences which result from the addition of additional amino acid residues to the polypeptides described herein are also encompassed in the present invention. Such longer polypeptide sequences can be expected to have the same biological activity and specificity (e.g., cell tropism) as the polypeptides described above. While polypeptides having a substantial number of additional amino acids are not excluded, it is recognized that some large polypeptides may assume a configuration that masks the effective sequence, thereby preventing binding to a target (e.g., a member of the LRP receptor family such as LRP or LRP2). These derivatives could act as competitive antagonists. Thus, while the present invention encompasses polypeptides or derivatives of the polypeptides described herein having an extension, desirably the extension does not destroy the cell targeting activity of the polypeptides or its derivatives.

Other derivatives included in the present invention are dual polypeptides consisting of two of the same, or two different polypeptides, as described herein, covalently linked to one another either directly or through a spacer, such as by a short stretch of alanine residues or by a putative site for proteolysis (e.g., by cathepsin, see e.g., U.S. Patent No. 5,126,249 and European Patent No. 495 049). Multimers of the

polypeptides described herein consist of a polymer of molecules formed from the same or different polypeptides or derivatives thereof.

The present invention also encompasses polypeptide derivatives that are chimeric or fusion proteins containing a polypeptide described herein, or fragment thereof, linked at its amino- or carboxy-terminal end, or both, to an amino acid sequence of a different protein. Such a chimeric or fusion protein may be produced by recombinant expression of a nucleic acid encoding the protein. For example, a chimeric or fusion protein may contain at least 6 amino acids shared with one of the described polypeptides which desirably results in a chimeric or fusion protein that has an equivalent or greater functional activity.

Assays to identify peptidomimetics

As described above, non-peptidyl compounds generated to replicate the backbone geometry and pharmacophore display (peptidomimetics) of the polypeptides described herein often possess attributes of greater metabolic stability, higher potency, longer duration of action, and better bioavailability.

Peptidomimetics compounds can be obtained using any of the numerous approaches in combinatorial library methods known in the art, including biological libraries, spatially addressable parallel solid phase or solution phase libraries, synthetic library methods requiring deconvolution, the 'one-bead one-compound' library method, and synthetic library methods using affinity chromatography selection. The biological library approach is limited to peptide libraries, while the other four approaches are applicable to peptide, non-peptide oligomer, or small molecule libraries of compounds (Lam, *Anticancer Drug Des.* 12:145, 1997). Examples of methods for the synthesis of molecular libraries can be found in the art, for example, in: DeWitt et al. (*Proc. Natl. Acad. Sci. USA* 90:6909, 1993); Erb et al. (*Proc. Natl. Acad. Sci. USA* 91:11422, 1994); Zuckermann et al. (*J. Med. Chem.* 37:2678, 1994); Cho et al. (*Science* 261:1303, 1993); Carell et al. (*Angew. Chem, Int. Ed. Engl.* 33:2059, 1994 and *ibid* 2061); and in Gallop et al. (*Med. Chem.* 37:1233, 1994). Libraries of compounds may be presented in solution (e.g., Houghten, *Biotechniques* 13:412-421, 1992) or on beads (Lam, *Nature* 354:82-84, 1991), chips (Fodor, *Nature* 364:555-556, 1993), bacteria or spores (U.S. Patent No. 5,223,409), plasmids (Cull et al., *Proc. Natl. Acad. Sci. USA* 89:1865-1869, 1992) or on phage

(Scott and Smith, *Science* 249:386-390, 1990), or luciferase, and the enzymatic label detected by determination of conversion of an appropriate substrate to product.

Once a polypeptide as described herein is identified, it can be isolated and purified by any number of standard methods including, but not limited to, differential solubility (e.g., precipitation), centrifugation, chromatography (e.g., affinity, ion exchange, and size exclusion), or by any other standard techniques used for the purification of peptides, peptidomimetics, or proteins. The functional properties of an identified polypeptide of interest may be evaluated using any functional assay known in the art. Desirably, assays for evaluating downstream receptor function in intracellular signaling are used (e.g., cell proliferation).

For example, the peptidomimetics compounds of the present invention may be obtained using the following three-phase process: (1) scanning the polypeptides described herein to identify regions of secondary structure necessary for targeting the particular cell types described herein; (2) using conformationally constrained dipeptide surrogates to refine the backbone geometry and provide organic platforms corresponding to these surrogates; and (3) using the best organic platforms to display organic pharmocophores in libraries of candidates designed to mimic the desired activity of the native polypeptide. In more detail the three phases are as follows. In phase 1, the lead candidate polypeptides are scanned and their structure abridged to identify the requirements for their activity. A series of polypeptide analogs of the original are synthesized. In phase 2, the best polypeptide analogs are investigated using the conformationally constrained dipeptide surrogates. Indolizidin-2-one, indolizidin-9-one and quinolizidinone amino acids (I^2aa, I^9aa and Qaa respectively) are used as platforms for studying backbone geometry of the best peptide candidates. These and related platforms (reviewed in Halab et al., *Biopolymers* 55:101-122, 2000 and Hanessian et al., *Tetrahedron* 53:12789-12854, 1997) may be introduced at specific regions of the polypeptide to orient the pharmacophores in different directions. Biological evaluation of these analogs identifies improved lead polypeptides that mimic the geometric requirements for activity. In phase 3, the platforms from the most active lead polypeptides are used to display organic surrogates of the pharmacophores responsible for activity of the native peptide. The pharmacophores and scaffolds are combined in a parallel synthesis format.

Derivation of polypeptides and the above phases can be accomplished by other means using methods known in the art.

Structure function relationships determined from the polypeptides, polypeptide derivatives, peptidomimetics or other small molecules described herein may be used to refine and prepare analogous molecular structures having similar or better properties. Accordingly, the compounds of the present invention also include molecules that share the structure, polarity, charge characteristics and side chain properties of the polypeptides described herein.

In summary, based on the disclosure herein, those skilled in the art can develop peptides and peptidomimetics screening assays which are useful for identifying compounds for targeting an agent to particular cell types (e.g., those described herein). The assays of this invention may be developed for low-throughput, high-throughput, or ultra-high throughput screening formats. Assays of the present invention include assays amenable to automation.

Linkers

The polypeptide therapeutic (e.g., neurotensin) may be bound to the vector peptide either directly (e.g., through a covalent bond such as a peptide bond) or may be bound through a linker. Linkers include chemical linking agents (e.g., cleavable linkers) and peptides.

In some embodiments, the linker is a chemical linking agent. The polypeptide therapeutic and peptide vector may be conjugated through sulfhydryl groups, amino groups (amines), and/or carbohydrates or any appropriate reactive group. Homobifunctional and heterobifunctional cross-linkers (conjugation agents) are available from many commercial sources. Regions available for cross-linking may be found on the polypeptides of the present invention. The cross-linker may comprise a flexible arm, e.g., 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, or 15 carbon atoms. Exemplary cross-linkers include BS3 ([Bis(sulfosuccinimidyl)suberate]; BS3 is a homobifunctional N-hydroxysuccinimide ester that targets accessible primary amines), NHS/EDC (N-hydroxysuccinimide and N-ethyl-'(dimethylaminopropyl)carbodimide; NHS/EDC allows for the conjugation of primary amine groups with carboxyl groups), sulfo-EMCS ([N-e-Maleimidocaproic acid]hydrazide; sulfo-EMCS are heterobifunctional reactive groups (maleimide and

NHS-ester) that are reactive toward sulfhydryl and amino groups), hydrazide (most proteins contain exposed carbohydrates and hydrazide is a useful reagent for linking carboxyl groups to primary amines), and SATA (N-succinimidyl-S-acetylthioacetate; SATA is reactive towards amines and adds protected sulfhydryls groups).

To form covalent bonds, one can use as a chemically reactive group a wide variety of active carboxyl groups (e.g., esters) where the hydroxyl moiety is physiologically acceptable at the levels required to modify the peptide. Particular agents include N-hydroxysuccinimide (NHS), N-hydroxy-sulfosuccinimide (sulfo-NHS), maleimide-benzoyl-succinimide (MBS), gamma-maleimido-butyryloxy succinimide ester (GMBS), maleimido propionic acid (MPA) maleimido hexanoic acid (MHA), and maleimido undecanoic acid (MUA).

Primary amines are the principal targets for NHS esters. Accessible α-amine groups present on the N-termini of proteins and the ε-amine of lysine react with NHS esters. An amide bond is formed when the NHS ester conjugation reaction reacts with primary amines releasing N-hydroxysuccinimide. These succinimide containing reactive groups are herein referred to as succinimidyl groups. In certain embodiments of the invention, the functional group on the protein will be a thiol group and the chemically reactive group will be a maleimido-containing group such as gamma-maleimide-butrylamide (GMBA or MPA). Such maleimide containing groups are referred to herein as maleido groups.

The maleimido group is most selective for sulfhydryl groups on peptides when the pH of the reaction mixture is 6.5-7.4. At pH 7.0, the rate of reaction of maleimido groups with sulfhydryls (e.g., thiol groups on proteins such as serum albumin or IgG) is 1000-fold faster than with amines. Thus, a stable thioether linkage between the maleimido group and the sulfhydryl can be formed.

In other embodiments, the linker includes at least one amino acid (e.g., a peptide of at least 2, 3, 4, 5, 6, 7, 10, 15, 20, 25, 40, or 50 amino acids). In certain embodiments, the linker is a single amino acid (e.g., any naturally occurring amino acid such as Cys). In other embodiments, a glycine-rich peptide such as a peptide having the sequence $[\text{Gly-Gly-Gly-Gly-Ser}]_n$ where n is 1, 2, 3, 4, 5 or 6 is used, as described in U.S. Patent No. 7,271,149. In other embodiments, a serine-rich peptide linker is used, as described in U.S. Patent No. 5,525,491. Serine rich peptide linkers include those of the formula $[\text{X-X-X-X-Gly}]_y$, where up to two of the X are Thr, and

the remaining X are Ser, and y is 1 to 5 (e.g., Ser-Ser-Ser-Ser-Gly, where y is greater than 1). In some cases, the linker is a single amino acid (e.g., any amino acid, such as Gly or Cys).

Examples of suitable linkers are succinic acid, Lys, Glu, and Asp, or a dipeptide such as Gly-Lys. When the linker is succinic acid, one carboxyl group thereof may form an amide bond with an amino group of the amino acid residue, and the other carboxyl group thereof may, for example, form an amide bond with an amino group of the peptide or substituent. When the linker is Lys, Glu, or Asp, the carboxyl group thereof may form an amide bond with an amino group of the amino acid residue, and the amino group thereof may, for example, form an amide bond with a carboxyl group of the substituent. When Lys is used as the linker, a further linker may be inserted between the ε-amino group of Lys and the substituent. In one particular embodiment, the further linker is succinic acid which, e.g., forms an amide bond with the ε- amino group of Lys and with an amino group present in the substituent. In one embodiment, the further linker is Glu or Asp (e.g., which forms an amide bond with the ε-amino group of Lys and another amide bond with a carboxyl group present in the substituent), that is, the substituent is a N^{ε}-acylated lysine residue.

Neurotensin agonist activity assay

Determination of whether a compound has neurotensin agonist activity can be performed using any method known in the art. Activity at the neurotensin receptor can measured, for example, by release of inositol phosphates. Inositol phosphate production from cells expressing a neurotensin receptor (e.g., a human or rat receptor) can be measured in the presence and in the absence of a compound, where an increase in inositol phosphate production indicates the compound to be a neurotensin receptor agonist.

In one example described in Watson et al., J Neurochem 59:1967-1970, 1992, Chinese hamster ovary (CHO) cells were transformed with the rat neurotensin receptor. Binding of neurotensin agonists can be measured by contacting detectably labeled neurotensin (e.g., labeled with ^{3}H), and measuring competition with a test compound. Second messagner synthesis (D-*myo*-inositol 1-phospate (IP_1)) can

measured by prelabeling cells with D-*myo*-[^{3}H]inositol. Production of [^{3}H]Inositol 1-phosphate is isolated by anion exchange chromatorgraphy.

Therapeutic applications

The compounds of the invention can be used in any appropriate therapeutic application where the activity of neurotensin activity is beneficial. Neurotensin (NT) is a 13 amino acid peptide found in the central nervous system and in the gastrointestinal tract. In brain, NT is associated with dopaminergic receptors and other neurotransmitter systems. Peripheral NT acts as a paracrine and endocrine peptide on both the digestive and cardiovascular systems. Various therapeutic applications have been suggested for neurotensin, including psychiatric disorders, metabolic disorder, and pain. Because neurotensin has been shown to modulate neurotransmission in areas of the brain associated with schizophrenia, neurotensin and neurotensin receptor agonists have been proposed as antipsychotic agents.

Neurological disease

Because polypeptides described herein are capable of transporting an agent across the BBB, the compounds of the invention are also useful for the treatment of neurological diseases such as neurodegenerative diseases or other conditions of the central nervous system (CNS), the peripheral nervous system, or the autonomous nervous system (e.g., where neurons are lost or deteriorate). Neurotensin has been suggested an antipsychotic therapy, and thus may be useful in the treatment of diseases such as schizophrenia and bipolar disorder. Many neurodegenerative diseases are characterized by ataxia (i.e., uncoordinated muscle movements) and/or memory loss. Neurodegenerative diseases include Alexander disease, Alper disease, Alzheimer's disease, amyotrophic lateral sclerosis (ALS; i.e., Lou Gehrig's disease), ataxia telangiectasia, Batten disease (Spielmeyer-Vogt-Sjogren-Batten disease), bovine spongiform encephalopathy (BSE), Canavan disease, Cockayne syndrome, corticobasal degeneration, Creutzfeldt-Jakob disease, Huntington's disease, HIV-associated dementia, Kennedy's disease, Krabbé disease, Lewy body dementia, Machado-Joseph disease (Spinocerebellar ataxia type 3), multiple sclerosis, multiple system atrophy, narcolepsy, neuroborreliosis, Parkinson's disease, Pelizaeus-Merzbacher disease, Pick's disease, primary lateral sclerosis, prion diseases,

Refsum's disease, Schilder's disease (i.e., adrenoleukodystrophy), schizophrenia, spinocerebellar ataxia, spinal muscular atrophy, Steele-Richardson, Olszewski disease, and tabes dorsalis.

Other neurological and psychiatric diseases that may be treated with the compounds of the invention include Tourette's syndrome and obsessive compulsive disorder.

Inducing body temperature reduction

The compounds of the invention may be used to reduce the body temperature of a subject. Because reduction in body temperature has been shown to be beneficial in subjects who who are in need of neuroprotection, e.g., may be suffering from, or may have recently suffered from, a stroke, cerebral ischemia, cardiac ischemia, or a nerve injury such as a spinal chord injury or head or brain injury (e.g., traumatic brain injury), such a treatment would therefore be useful in reducing complications of these conditions. Reduction of body temperature may also be desired during surgical procedures such as cardiac surgery (e.g., open heart surgery) or other major surgery or where the subject is suffering from malignant hypothermia.

Pain

Neurotensin is also known to have analgesic effects. Thus the compounds of the invention may be used to reduce pain in a subject. The subject may be suffering from an acute pain (e.g., selected from the group consisting of mechanical pain, heat pain, cold pain, ischemic pain, and chemical-induced pain). Other types of pain include peripheral or central neuropathic pain, inflammatory pain, migraine-related pain, headache-related pain, irritable bowel syndrome-related pain, fibromyalgia-related pain, arthritic pain, skeletal pain, joint pain, gastrointestinal pain, muscle pain, angina pain, facial pain, pelvic pain, claudication, postoperative pain, post traumatic pain, tension-type headache, obstetric pain, gynecological pain, or chemotherapy-induced pain.

Metabolic disorders

There is evidence that neurotensin can be used to treat metabolic disorders; see, e.g., U.S. Patent Application No. 2001/0046956. Thus the compounds of the

invention may be used to treat such disorders. The metabolic disorder may be diabetes (e.g., Type I or Type II), obesity, diabetes as a consequence of obesity, hyperglycemia, dyslipidemia, hypertriglyceridemia, syndrome X, insulin resistance, impaired glucose tolerance (IGT), diabetic dyslipidemia, hyperlipidemia, a cardiovascular disease, or hypertension. The subject may be overweight, obese, or bulimic.

Drug addiction/abuse

Neurotensin has also been suggested to be able to treat drug addiction or reduce drug abuse in subjects, particularly with psychostimulants. Thus the compounds of the invention may be useful in treating addiction to or abuse of drugs such as amphetamine, methamphetamine, 3,4-methylenedioxymethamphetamine, nicotine, cocaine, methylphenidate, and arecoline. NT may also be used to treat alcohol addiction.

Administration and dosage

The present invention also features pharmaceutical compositions that contain a therapeutically effective amount of a compound of the invention. The composition can be formulated for use in a variety of drug delivery systems. One or more physiologically acceptable excipients or carriers can also be included in the composition for proper formulation. Suitable formulations for use in the present invention are found in *Remington's Pharmaceutical Sciences*, Mack Publishing Company, Philadelphia, PA, 17th ed., 1985. For a brief review of methods for drug delivery, see, e.g., Langer (*Science* 249:1527-1533, 1990).

The pharmaceutical compositions are intended for parenteral, intranasal, topical, oral, or local administration, such as by a transdermal means, for prophylactic and/or therapeutic treatment. The pharmaceutical compositions can be administered parenterally (e.g., by intravenous, intramuscular, or subcutaneous injection), or by oral ingestion, or by topical application or intraarticular injection at areas affected by the vascular or cancer condition. Additional routes of administration include intravascular, intra-arterial, intratumor, intraperitoneal, intraventricular, intraepidural, as well as nasal, ophthalmic, intrascleral, intraorbital, rectal, topical, or aerosol inhalation administration. Sustained release administration is also specifically

included in the invention, by such means as depot injections or erodible implants or components. Thus, the invention provides compositions for parenteral administration that comprise the above mention agents dissolved or suspended in an acceptable carrier, preferably an aqueous carrier, e.g., water, buffered water, saline, PBS, and the like. The compositions may contain pharmaceutically acceptable auxiliary substances as required to approximate physiological conditions, such as pH adjusting and buffering agents, tonicity adjusting agents, wetting agents, detergents and the like. The invention also provides compositions for oral delivery, which may contain inert ingredients such as binders or fillers for the formulation of a tablet, a capsule, and the like. Furthermore, this invention provides compositions for local administration, which may contain inert ingredients such as solvents or emulsifiers for the formulation of a cream, an ointment, and the like.

These compositions may be sterilized by conventional sterilization techniques, or may be sterile filtered. The resulting aqueous solutions may be packaged for use as is, or lyophilized, the lyophilized preparation being combined with a sterile aqueous carrier prior to administration. The pH of the preparations typically will be between 3 and 11, more preferably between 5 and 9 or between 6 and 8, and most preferably between 7 and 8, such as 7 to 7.5. The resulting compositions in solid form may be packaged in multiple single dose units, each containing a fixed amount of the above-mentioned agent or agents, such as in a sealed package of tablets or capsules. The composition in solid form can also be packaged in a container for a flexible quantity, such as in a squeezable tube designed for a topically applicable cream or ointment.

The compositions containing an effective amount can be administered for prophylactic or therapeutic treatments. In prophylactic applications, compositions can be administered to a subject with a clinically determined predisposition or increased susceptibility to a metabolic disorder or neurological disease. Compositions of the invention can be administered to the subject (e.g., a human) in an amount sufficient to delay, reduce, or preferably prevent the onset of clinical disease. In therapeutic applications, compositions are administered to a subject (e.g., a human) already suffering from disease (e.g., a metabolic disorder such as those described herein, or a neurological disease) in an amount sufficient to cure or at least partially arrest the symptoms of the condition and its complications. An amount adequate to accomplish this purpose is defined as a "therapeutically effective amount," an amount of a

compound sufficient to substantially improve some symptom associated with a disease or a medical condition. For example, in the treatment of a metabolic disorder (e.g., those described herein), an agent or compound which decreases, prevents, delays, suppresses, or arrests any symptom of the disease or condition would be therapeutically effective. A therapeutically effective amount of an agent or compound is not required to cure a disease or condition but will provide a treatment for a disease or condition such that the onset of the disease or condition is delayed, hindered, or prevented, or the disease or condition symptoms are ameliorated, or the term of the disease or condition is changed or, for example, is less severe or recovery is accelerated in an individual.

Amounts effective for this use may depend on the severity of the disease or condition and the weight and general state of the subject, but generally range from about 0.05 μg to about 1000 μg (e.g., 0.5-100 μg) of an equivalent amount of exendin-4 the agent or agents per dose per subject. Suitable regimes for initial administration and booster administrations are typified by an initial administration followed by repeated doses at one or more hourly, daily, weekly, or monthly intervals by a subsequent administration. The total effective amount of an agent present in the compositions of the invention can be administered to a mammal as a single dose, either as a bolus or by infusion over a relatively short period of time, or can be administered using a fractionated treatment protocol, in which multiple doses are administered over a more prolonged period of time (e.g., a dose every 4-6, 8-12, 14-16, or 18-24 hours, or every 2-4 days, 1-2 weeks, once a month). Alternatively, continuous intravenous infusion sufficient to maintain therapeutically effective concentrations in the blood are contemplated.

The therapeutically effective amount of one or more agents present within the compositions of the invention and used in the methods of this invention applied to mammals (e.g., humans) can be determined by the ordinarily-skilled artisan with consideration of individual differences in age, weight, and the condition of the mammal. Because certain compounds of the invention exhibit an enhanced ability to cross the BBB, the dosage of the compounds of the invention can be lower than (e.g., less than or equal to about 90%, 75%, 50%, 40%, 30%, 20%, 15%, 12%, 10%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, 0.5%, or 0.1% of) the equivalent dose of required for a therapeutic effect of the unconjugated agonist. The agents of the invention are

administered to a subject (e.g. a mammal, such as a human) in an effective amount, which is an amount that produces a desirable result in a treated subject (e.g. reduction in glycemia, reduced weight gain, increased weight loss, and reduced food intake). Therapeutically effective amounts can also be determined empirically by those of skill in the art.

The subject may also receive an agent in the range of about 0.05 to 10,000 μg equivalent dose as compared to neurotensin per dose one or more times per week (e.g., 2, 3, 4, 5, 6, or 7 or more times per week), 0.1 to 2,500 (e.g., 2,000, 1,500, 1,000, 500, 100, 10, 1, 0.5, or 0.1) μg dose per day or week. A subject may also receive an agent of the composition in the range of 0.1 to 3,000 μg per dose once every two or three weeks.

Single or multiple administrations of the compositions of the invention comprising an effective amount can be carried out with dose levels and pattern being selected by the treating physician. The dose and administration schedule can be determined and adjusted based on the severity of the disease or condition in the subject, which may be monitored throughout the course of treatment according to the methods commonly practiced by clinicians or those described herein.

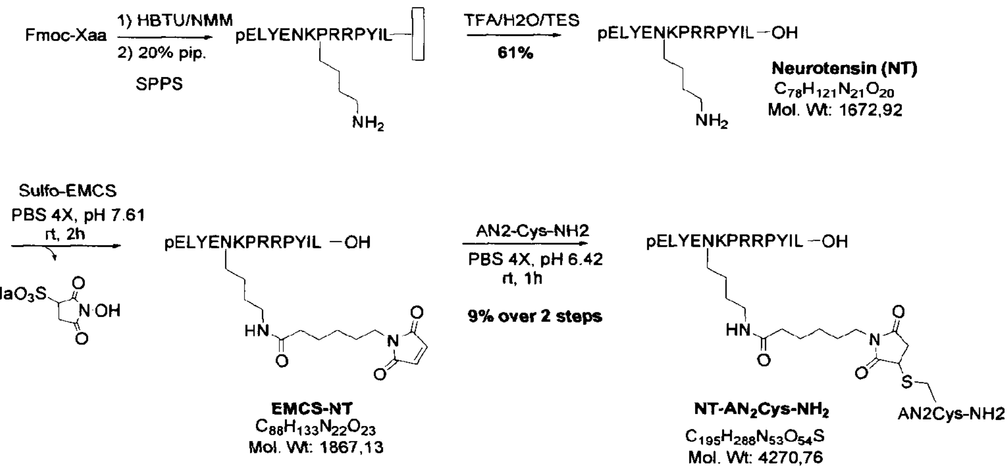
The compounds of the present invention may be used in combination with either conventional methods of treatment or therapy or may be used separately from conventional methods of treatment or therapy.

When the compounds of this invention are administered in combination therapies with other agents, they may be administered sequentially or concurrently to an individual. Alternatively, pharmaceutical compositions according to the present invention may be comprised of a combination of a compound of the present invention in association with a pharmaceutically acceptable excipient, as described herein, and another therapeutic or prophylactic agent known in the art.

Example 1

Synthesis of a neurotensin-Angiopep-2 conjugate

An exemplary neurotensin-Angiopep-2 conjugate was synthesized using the scheme described below. As used in these examples, the abbreviation NT refers to the pE-substituted neurotensin peptide described below.



Neurotensin peptide synthesis

pELYENKPRRPYIL-OH, where the unusual amino acid L-pyroglutamic acid (pE) is used, was synthesized using SPPS (Solid phase peptide synthesis). SPPS was carried out on a Protein Technologies, Inc. *Symphony®* peptide synthesizer using Fmoc (9-fluorenylmethyloxycarbonyl) amino-terminus protection. The peptide was synthesized on a 100 μmol scale using a 5-fold excess of Fmoc-amino acids (200 mM) relative to the resin. Coupling was performed by a pre-loaded Fmoc-Leu-Wang resin (0.48 mmol/g) for carboxyl-terminus acids using 1:1:2 amino acid/activator/NMM in DMF with HBTU (2-(1H-benzotriazol-1-yl)-1,1,3,3-tetramethyluronium hexafluorophosphate) and NMM (*N*-methylmorpholine). Deprotection was carried out using 20% piperidine/DMF. The resin-bound product was routinely cleaved using a solution comprised of TFA/water/TES: 95/2.5/2.5 for 2 hours at room temperature.

Pre-loaded Fmoc-Leu-Wang resin (0.48 mmol/g) was purchased from ChemPep, Fmoc-amino acids, HBTU from ChemImpex, and the unusual L-pyroglutamic acid from Sigma-Aldrich. Side protecting groups for amino acids were Trt (trityl) for aspargine, tBu (ter-butyl) for glutamic acid and tyrosine, Pbf (pentamethyldihydrobenzofuran-5-sulfonyl) for arginine, and tBoc (tButyloxycarbonyl) for lysine.

The crude peptide was precipitated using ice-cold ether, and purified by RP-HPLC chromatography (Waters Delta Prep 4000). Acetonitrile was evaporated from the collected fractions and lyophilized to give a pure white solid (204 mg, 61%, purity

>98%). The mass was confirmed by ESI-TOF MS (Bruker Daltonics; calculated 1672.92; found 1671.90, m/z 558.31 (+3), 836.96 (+2)).

EMCS-NT

The *N*-lysine primary amine of NT was activated by treating a solution of NT (25 mg, 14.9 μmol, 1 eq. in 3.5 ml of PBS 4X, pH 7.64), with a solution of sulfo-EMCS (*N*-[ε-maleimidocaproyloxy]sulfosuccinimide ester) (Pierce Biotechnology) (6.1 mg, 14.9 μmol, 1 eq. in 1 ml of PBS 4X). Monitoring of the reaction was done with the analytical method described below (see chromatograms 1-2 in Figures 1A and 1B). The reaction (3.32 mM, pH 7.61) allowed proceeding at room temperature for 1 h. The modification was repeated once for 1 h with addition of sulfo-EMCS (4.5 mg, 10.9 μmol, 0.73 eq. in 1 ml of PBS 4X). The mixture was purified by FPLC chromatography (AKTA explorer, see chromatogram 3 in Figure 2). Purification of EMCS-NT was performed on a column containing 30 RPC resin (polystyrene/divinyl benzene), 30 ml. Sample was loaded as 35 mg in reaction buffer (4 ml), 10 % acetonitrile (ACN) in H_2O, 0.05% TFA (200 μl). Solution A was H_2O, 0.05 % TFA, and Solution B was ACN, 0.05 % TFA. Flow rate 5-9 ml/min with a gradient of 10-25 % of Solution B.

After the acetonitrile was evaporated, the volume of water was reduced to 5 ml for the next step. A colorless solution of the pure EMCS-modified NT (purity >98 %) was obtained. The mass was checked by ESI-TOF MS (Bruker Daltonics), was calculated to be 1867.13, and was found to be 1866.00, m/z 623.01 (+3), 934.00 (+2).

NT-AN2Cys-NH2

Conjugation was performed with the maleimido-containing EMCS-NT and the free thiol residue of AN2Cys-NH_2. The pH of the solution of EMCS-NT was adjusted from 1.65 to 6.42 by a slow addition of a 0.1N NaOH solution. A hydrolysis side reaction can occur during adjustment of pH (≤5%, hydrolyzed EMCS-NT Mw=1833). A solution of AN2Cys-NH_2 (46.4 mg, 14.9 μmol, 1 eq. in 2.5 ml of PBS 4x, pH 7.64) was added to the solution of EMCS-NT. The analytical method below was used to monitoring the reaction (see chromatograms 4-5 in Figures 3A and 3B). The reaction (1.9 mM, pH 6.3) was allowed to proceed at room temperature for 30 minutes. The mixture was purified by FPLC chromatography (AKTA explorer, see chromatogram 6

in Figure 4). Purification of NT-AN2Cys-NH2 was performed using a column (GE Healthcare) containing 30 RPC resin (Polystyrene/divinyl benzene), 30 ml, Sample was loaded in the amount of 74 mg in 4 ml reaction buffer (10 % ACN in H_2O, 0.05% TFA (200 ul)). Solution A was H_2O, 0.05 % TFA, and Solution B was ACN, 0.05 % TFA. The flow rate was 5-9 ml/min, using a gradient of 10% to 25% of Solution B.

After evaporation of acetonitrile and lyophilization, the conjugated NT-AN2Cys-NH_2 was obtained as a pure white solid (5.5 mg, 9% over 2 steps, purity >95%). The mass was confirmed by ESI-TOF MS (Bruker Daltonics); MW was calculated to be 4270.76 and was found to be 4269.17 (m/z 712.54 (+6), 854.84 (+5), 1068.29 (+4), 1424.04 (+3)).

The conjugate was stored under nitrogen atmosphere, below -20°C.

Analytical method

The following method was used as described above. To analyze samples during purification, a Waters Acquity UPLC system was employed with a BEH phenyl column, 1.7 μm, 2.1 x 50 mm Detection was performed at 229 nm. Solution A was H_2O, 0.1% FA, and Solution B was acetonitrile (ACN), 0.1% FA. Flow rate was 0.5 ml/min with a gradient of 10-90% B, as shown in the table below.

Time (min)	Flow (mL/min)	%A	%B	Curve
	0.5	90	10	
0.40	0.5	90	10	6
0.70	0.5	70	30	6
2.20	0.5	30	70	6
2.40	0.5	10	90	6
2.70	0.5	10	90	6
2.80	0.5	90	10	6
2.81	0.5	90	10	6

Example 2

Characterization of the NT-AN2Cys-NH_2 conjugate

To investigate the pharmacological efficacy and brain penetration of the NT-AN2Cys-NH_2 (NT-An2) conjugate, we monitored its effect on the body temperature of mice (Figure 5). The temperature of mice was unaffected by intravenous administration of 1 mg/kg NT or the saline control. By contrast, intravenous administration of an equivalent dose of the conjugate (2.5 mg/kg) resulted in a rapid decrease in the body temperature, leading to hypothermia. The injection of a higher

dose (5 mg/kg) of NT-An2 caused a stronger decrease in body temperature indicating that the effect of NT-An2 is dose dependent.

We also tested whether higher doses of the conjugate would results in greater induction of hypothermia. Mice were administered 5, 15, or 20 mg/kg of the conjugate, and the reduction in body temperature following administration was monitored for 120 minutes following administration. Small differences between these higher doses were observed (Figure 6).

This experiment was repeated again with a second small batch of the NT-An2 compound, which resulted in similar activity. A third batch, which was produced as a part of an attempt to scale up the production, exhibited similar but somewhat lower activity, as shown in Figure 7.

To confirm that the NT-An2 conjugate crosses the BBB, both NT and the conjugate were iodinated using standard procedures, and in situ brain perfusion was performed using methods standard in the art. The initial transport was measured as a function of time (Figure 8). Results clearly indicate that the initial brain uptake for the NT-An2 conjugate is higher than for the unconjugated NT. Furthermore, after a 2 min in situ perfusion, capillary depletion was done to quantify the amount of NT-An2 found in the brain parenchyma (Figure 9). Higher levels of NT-An2 were found in the brain parenchyma when compared to NT. In addition, these results indicate that NT-An2 is not trapped in the brain capillaries. Overall, our results demonstrate that the new NT-An2 derivative crosses the BBB at a sufficient concentration required to activate its receptors involved in the control of the body temperature.

Example 3

Induction of sustained hypothermia using Angiopep-NT conjugates

We performed an additional experiments to test whether the conjugates were able to induce sustained hypothermia in mice and rats.

In a first experiment, mice first received an intravenous 5 mg/kg bolus injection of NT-An2, followed by an intravenous infusion (10 mg/kg/hr) 1 hour later for a duration of 2.5 hours. The body temperature continued to decrease during the infusion, reaching a nadir of -11°C (Figure 10). After the end of the infusion, body temperature slowly returned to 37°C, and the animals recovered.

A similar experiment was performed in rats. Here the rats were administered an intravenous bolus injection of 20 mg/kg NT-An2 immediately followed by a 20 mg/kg/hr infusion for 3.5 hours. This resulted in a maximal temperature drop of about 3.5 °C after 90 minutes (Figure 11).

Sustained hypothermia experiments were performed using a intravenous bolus injection of 20 mg/kg of NT-An2 immediately followed by a 20 mg/kg/hr infusion for 2.5 hours. At this time, the infusion was increased to 40 mg/kg/hr. A reduction in body temperature for the initial 37 °C was observed over the 360 minute time course of the experiment (Figure 12).

A similar experiment was conducted in rats. In this experiment, rats were injected intravenously with 20 mg/kg of NT-An2 immediately followed by a 20 mg/kg/hr infusion. A sustained reduction in body temperature was also observed during the 360-minute time course of this experiment (Figure 13).

A further experiment, conducted over a 12-hour period, was also performed in rats. This experiment involved a 40 mg/kg intravenous bolus injection of NT-An2 followed immediately by a 20 mg/kg/hr infusion of NT-An2. As shown in Figure 14, this resulted in a prolonged reduction of body temperature over the course of the experiment.

Example 4

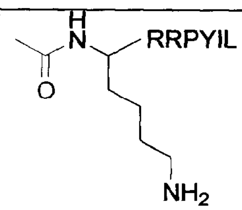
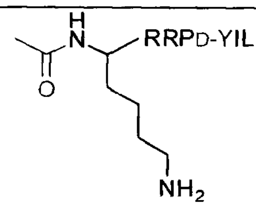
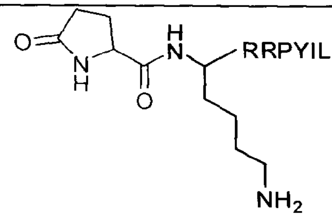
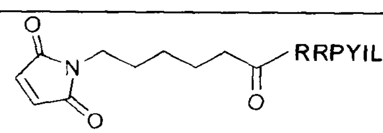
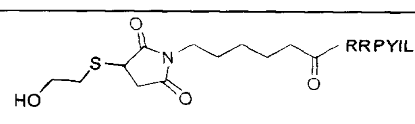
Analgesia induction by NT-An2

We also tested the ability of NT-An2 to induce analgesia in mice. We tested the latency between hot plate foot exposure and foot licking behavior in control mice, mice receiving 20 mg/kg NT-An2, and mice receiving 1 mg/kg of buprenorphine (an opiate analgesic) as a positive control. Both the NT-An2 and the buprenorphine increased the latency of foot licking behavior in a statistically significant manner 15 minutes following injection, thus indicating that NT-An2 can act as an analgesic (Figure 15).

Example 5

Generation of shorter neurotensin analogs

We further generated several shorter neurotensin analogs. These analogs include NT(8-13) (RRPYIL), Ac-LysNT(8-13), Ac-Lys-[D-Tyr^{11}]NT(8-13), pGlu-LysNT(8-13), MHA-NT(8-13), and β-mercaptoMHA-NT(8-13) (see below).

Name	Sequence	Mw (g/mol)	Qtty (mg)
NT native	pELYENKPRRPYIL	1672.97	800, ≥95%
NT(8-13)	RRPYIL	816.99	45, ≥95%
Ac-LysNT(8-13)		987.20	78, ≥95%
Ac-Lys-[D-Tyr^{11}]NT(8-13)		987.20	55, ≥95%
pGlu-LysNT(8-13)		1056.26	86, ≥95%
MHA-NT(8-13)		1010.19	55, ≥95%
β-mercaptoMHA-NT(8-13) (desactive)		1088.32	12, ≥95%

NT and the NT(8-13) analogs were synthesized by using a SPPS method on a Protein Technologies, Inc. *Symphony*® peptide synthesizer and Fmoc chemistry. Pre-loaded Fmoc-Leu-Wang resin (0.48 mmol/g) was purchased from ChemPep, Fmoc-

amino acids, HBTU from ChemImpex, the unusual pE from Sigma-Aldrich, unnatural D-Tyrosine from ChemImpex, Sulfo-EMCS from Pierce Biotechnology. Side protecting groups for amino acids were Trt for aspargine, tBu for glutamic acid and tyrosine, Pbf for arginine, and tBoc for lysine. Mass was confirmed by ESI-TOF MS (MicroTof, Bruker Daltonics).

General procedure - Synthesis of neurotensin (NT) (pELYENKPRRPYIL-OH). NT was synthesized using the unusual L-pyroglutamic acid (pE) and a 5 fold excess of Fmoc-AA (200mM) relative to the resin. Coupling was performed from a pre-loaded Fmoc-Leu-Wang resin (0.48 mmol/g) for carboxyl-terminus acids using 1:1:4 AA/HBTU/NMM in DMF. Deprotection was carried out using 20% piperidine/DMF. The resin-bound product was routinely cleaved using a cocktail solution comprised of TFA/water/TES : 95/2.5/2.5 for 2 h at room temperature.

The crude peptide was precipitated using ice-cold ether and was purified by RP-HPLC chromatography, Waters Delta Prep 4000, Kromasil 100-10-C18, H_2O/ACN with 0.05%TFA ("Method A"). Acetonitrile was evaporated from the collected fractions and lyophilized. This resulted in the formation of a white and fluffy solid, 800 mg, 80 % yield, purity HPLC >98 %, calc. 1672.92, found 1671.90, m/z 558.31 (+3), 836.96 (+2).

Synthesis of MHA-NT(8-13) (MHA-RRPYIL-OH). The same procedure was used as for NT. A 100mM Fmoc-AA solution, and TBTU were used. Prior to cleavage, the N-terminal MHA group was introduced on SPPS by treating the free N-terminal amino peptide bound to the resin with an 18 mM solution of Sulfo-EMCS (1.2 eq. in DMF) for 1.5 h at room temperature. The crude peptide was purified by RP-HPLC chromatography, Waters Delta Prep 4000, Waters BEH Phenyl, H_2O/ACN with 0.05%TFA ("Method B"). This generated 55 mg of product, 73 % yield, purity HPLC ≥95 %, calc. 1010.19, found 1010.59, m/z 505.81 (+2).

Synthesis of Ac-Lys-[D-Tyr^{11}]NT(8-13) (Ac-KRRPD-YIL-OH). The same procedure was used as for NT. D-Tyrosine, a 100mM Fmoc-AA solution, and TBTU were used. Before cleavage, a subsequent capping reaction was carried out using a large excess of 1:1:3 v/v/v acetic anhydride/DIEA/DMF for 10 min at room

temperature. The peptide was purified by Method A. This resulted in the formation of a white and fluffy solid, 426 mg, 82 % yield, purity HPLC ≥95 %, calc. 987.20, found 987.58, m/z 494.30 (+2).

Synthesis of ANG-Cys-NH2 (H-T^1FFYGG^{6}S^{7}RGKRNNFKTEEYC-NH2). ANG-Cys-NH2 was synthesized using a 5-fold excess of Fmoc-AA (200 mM) relative to the resin. **G^{6}S^7** is coupled as the pseudoproline dipeptide GS. Coupling was performed from a Rink amide MBHA resin with Nle (0.40 mmol/g) for carboxyl-terminus amides using 1:1:4 AA/HCTU/NMM in DMF. Cleavage of the resin-bound product was carried out using TFA/water/EDT/TES: 94/2.5/2.5/1 for 2 h at room temperature.

The crude peptide was precipitated using ice-cold ether, and purified by RP-HPLC chromatography twice successively, Waters Delta Prep 4000, Kromasil 100-10-C18 and Waters BEH Phenyl, H_2O/ACN with 0.05%TFA ("Method C"). Acetonitrile was evaporated from the collected fractions and lyophilized. This resulted in formation of a white and fluffy solid, 565 mg, 28 % yield, purity HPLC >90 %, calc. 2403.63; found 2402.05, m/z 1202.53 (+2), 802.04 (+3), 601.78 (+4).

General procedure - Synthesis of MHA-NT. NT (1 eq.) was dissolved in PBS 4x (pH 7.3), and the solution pH was adjusted to 7.1 by addition of NaOH 0.1 N solution. To this solution was added a solution of Sulfo-EMCS (1 eq. in PBS 4x). Monitoring of the reaction was done with an analytical method. The reaction (9.0 mM, pH 7.1) allowed proceeding at RT for 2 h. The pH of reaction was adjusted from 5.2 to 7 with addition of NaOH 0.1 N solution.

After a second addition of sulfo-EMCS (0.3 eq. in PBS 4x), the reaction was repeated for 1 h. The mixture was purified by FPLC chromatography, AKTA explorer, 30RPC resin, H_2O/ACN without acid ("Method D"). Before evaporation, the resulting pure pooled fractions were acidified to pH 4 with a solution of water, 0.1%TFA.

After acetonitrile was evaporated, the volume of water was reduced to a minimum volume to be engaged directly in the subsequent conjugation step. This resulted in a colorless solution, estimated to be 278 mg, 83 % yield, purity HPLC >98 %, calc. 1867.13, found 1866.00, m/z 623.01 (+3), 934.00 (+2).

Synthesis of AcLys(MHA)NT(8-13)(D-Tyr11). The same procedure as MHA-NT from AcLysNT(8-13)(D-Tyr11). After the first addition of the solution of Sulfo-EMCS (1 eq. in PBS 4x), the reaction (5.0 mM, pH 6.8) allowed proceeding at room temperature for 2 h. This produced a colorless solution, estimated to be 24 mg, 67 % yield, purity HPLC ≥95, calc. 1180.40, found 1180.64, m/z 590.83 (+2).

The following abbreviations are used in the description of the above synthetic methods.

AA	Amino acid
Ac	Acetyl group
ANG	Angiopep-2
DIEA	Di*iso*propylethylamine
DMF	Dimethylformamide
DMSO	Dimethylsulfoxide
Fmoc	9-Fluorenylmethyloxycarbonyl
HBTU	2-(1H-Benzotriazol-1-yl)-1,1,3,3-TetramethylUronium Hexafluorophosphate
HCTU	2-(1H-6-Chlorobenzotriazol-1-yl)-1,1,3,3-TetramethylUronium Hexafluorophosphate
MBHA	4-Methylbenzhydrylamine
MHA	Maleimidohexanoic acyl group
NMM	*N*-MethylMorpholine
NT	Neurotensin
Pbf	Pentamethyldihydrobenzofuran-5-sulfonyl
pE	L-pyroglutamic acid
SPPS	Solid Phase Peptide Synthesis
Sulfo-EMCS	*N*-[ε-maleimidocaproyloxy]sulfosuccinimide ester
tBoc	tButyloxycarbonyl
TBTU	2-(1H-Benzotriazol-1-yl)-1,1,3,3-TetramethylUronium Tetrafluoroborate
tBu	ter-butyl group
TES	Triethylsilane
TFA	Trifluoroacetic acid
Trt	Trityl group

Example 6

Characterization of neurotensin analogs

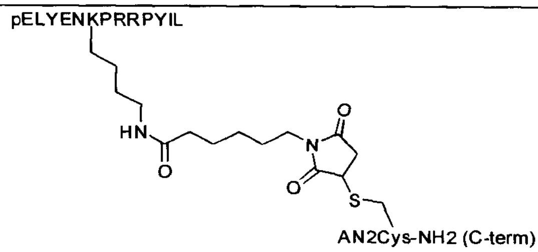
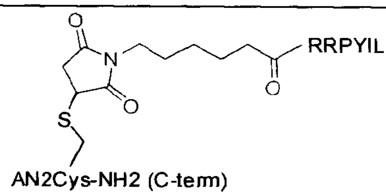
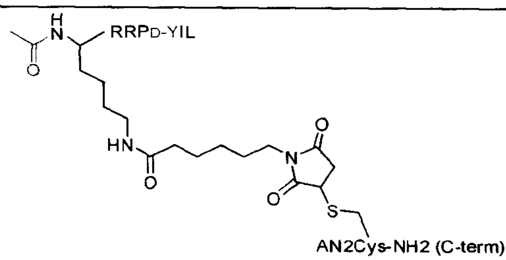
To determine which NT analog or analogs would be best suited for conjugation to Angiopep-2, we evaluated the ability of each analog to induce hypothermia in mice. Bolus intravenous injections of 7.5 mg/kg of NT(8-13), Ac-

Lys-NT(8-13), Ac-Lys-[D-Tyr^{11}]NT(8-13), pGlu-NT(8-13), and a control were performed (Figure 16) and body temperature was measured over a period of 120 minutes. Ac-Lys-[D-Tyr^{11}]NT(8-13) exhibited the greatest reduction in body temperature of the analogs tested. This analog was therefore selected for conjugation and further experimentation.

Example 7

Generation of neurotensin analog conjugates

Three neurotensin and NT analog conjugates were generated, NT-AN2 (as described above), NT(8-13)-AN2, and Ac-Lys-[D-Tyr^{11}]NT(8-13)-AN2. The structure of each of these conjugates is shown in the table below.

Name	Sequence	Mw (g/mol)	Qtty (mg)
NT-An2		4270.76	18, ≥95%
NT(8-13)-AN2		3413.82	59, ≥95%
Ac-Lys-[D-Tyr^{11}]NT(8-13)-AN2		3584.03	17, ≥95%

The conjugates analogs were synthesized by using a SPPS method on a Protein Technologies, Inc. *Symphony*® peptide synthesizer and Fmoc chemistry. Pre-loaded Fmoc-Leu-Wang resin (0.48 mmol/g) was purchased from ChemPep, Fmoc-amino acids, HBTU from ChemImpex, the unusual pE from Sigma-Aldrich, unnatural

D-Tyrosine from ChemImpex, Sulfo-EMCS from Pierce Biotechnology. Side protecting groups for amino acids were Trt for aspargine, tBu for glutamic acid and tyrosine, Pbf for arginine, and tBoc for lysine. Mass was confirmed by ESI-TOF MS (MicroTof, Bruker Daltonics). All abbreviations used in the following methods are defined in Example 5 above.

General procedure - Synthesis of ANG-NT. Conjugation was performed with the maleimido-containing MHA-NT and the free thiol residue of ANG-Cys-NH2.

The pH of the previously prepared solution of MHA-NT was adjusted from 4.2 to 5 by slow addition of a 0.1N NaOH solution. To this solution of MHA-NT was added a solution of ANG-Cys-NH2 (1 eq. in PBS 4X, pH 7.3). Monitoring of the reaction was done with an analytical method. The reaction (2.5 mM, pH 5.1) was allowed to proceed at room temperature for 1 h. The mixture was purified by FPLC chromatography, AKTA explorer, 30RPC resin, H_2O/ACN with 0.05 % TFA ("Method E").

After evaporation of acetonitrile and lyophilization, the conjugated ANG-NT was obtained as a pure white solid, 412 mg, 65% yield, 54 % over 2 steps, purity HPLC >95 %, calc. 4270.76, found 4269.17, m/z 712.54 (+6), 854.84 (+5), 1068.29 (+4), 1424.04 (+3).

Synthesis of ANG-NT(8-13). The same procedure as ANG-NT was used for MHA-NT(8-13) . MHA-NT(8-13) (1 eq.) was dissolved in DMSO (19 mM). The mixture was purified by Method B (see above). This resulted in a white and fluffy solid, 597 mg, 88 % yield, purity HPLC ≥95 %, calc. 3413.82, found 3413.46, m/z 683.75 (+5), 854.19 (+4), 1138.91 (+3).

Synthesis of ANG-AcLys-[D-Tyr^{11}]NT(8-13). The same procedure as ANG-NT was used for AcLys(MHA)- [D-Tyr^{11}]NT(8-13). The peptide was purified by Method E. This resuled in a white solid, 17 mg, 24 % yield, purity HPLC ≥95 %, calc. 3584.03, found 3583.79, m/z 598.30 (+6), 717.76 (+5), 896.70 (+4), 1195 (+3).

Example 8

Characterization of NT analog conjugates

To determine the ability of the NT analog conjugates to induce hypothermia, a bolus of a control, unconjugated NT, NT-An2, NT(8-13)-An2, and Ac-Lys-[D-Tyr^{11}]NT(8-13)-An2 were each injected intravenously into mice, and body temperature was monitored over a period of 120 minutes. Little difference between the control and the unconjugated NT, some effect was observed with the NT(8-13)-An2 conjugate, and a larger effect was observed with both the NT-An2 and Ac-Lys-[D-Tyr^{11}]NT(8-13)-An2 conjugates (Figure 17).

We also compared the ability of unconjugated Ac-Lys-[D-Tyr^{11}]NT(8-13) at 1 mg/kg to the Ac-Lys-[D-Tyr^{11}]NT(8-13)-An2 conjugate at 6.25 mg/kg to reduce body temperature. From these experiments, it was observed that the conjugate reduced body temperature to a greater extent than the unconjugated compound (Figure 18).

A bolus injection (6.25 mg/kg) of the Ac-Lys-[D-Tyr^{11}]NT(8-13)-An2 conjugate followed by a 6.25 mg/kg/hr infusion of this conjugate after one hour was also performed (Figure 19).

Example 9

Binding of NT and NT analogs and conjugates thereof to the NT receptor NTSR1

To further characterize NT, the NT analogs, and conjugates of NT, or NT analogs, a competitive binding assay using HT29 cells (human colon adenocarcinoma grade II cell line) that express the high affinity NTSR1 receptor was employed. As an initial test, we were able to demonstrate that [^{3}H]-neurotensin could be completely displaced from the cells by 40 nM of unlabeled NT (Figure 20). We then performed a dose response test between 0.4 nM and 40 nM. From these results, we determined that NT has an IC_{50} of 1.4 nM in this system (Figure 21).

We then compared the binding of NT to that of Ac-Lys-[D-Tyr^{11}]NT(8-13)-An2. From this experiment, the binding of this analog was observed to be over 1000-fold weaker than the native NT (IC_{50} of 3.5 nM vs. 5389 nM, as shown in Figure 22).

Using these methods, we compared both the binding and the induced body temperature reduction between neurotensin, NT analogs, and the conjugates. These

results are presented in the table below. The different results for NT and ANG-NT (i.e., NT-An2) represent results from different production batches of each compound.

Molecules	IC50 (nM)	Δ Max temp (oC)	Sustained hypothermia
NT			
prep #1	1.6	0	n.d.
prep #2	1.2-3.5	0	n.d.
BACHEM	4.0	0	n.d.
Phoenix Pharmaceutials	3.1	0	n.d.
NT analogs			
NT(8-13)	<1	0	n.d.
AcLysNT(8-13)D-tyr11	5389	- 3 (at high dose)	n.d.
AcLys-NT(8-13)	1	0	n.d.
pGlu-Lys-NT(8-13)	1.3	0	n.d.
β-mercapto-MHA-NT(8-13)	5	0	n.d.
ANG-NT conjugates			
ANG-NT (prep #1)	n.a.	-4 to -5	n.a.
ANG-NT (prep #2)	23.5 (glass)	-4 to -5	+++
ANG-NT (prep #3)	10	-3 to -4	+
ANG-NT (prep #4)	6.8	-2 to -4	-
ANG-NT(8-13)	4	0	n.d.
ANG-NT(8-13)(D-Tyr)	>100	-3 to -4	+

Other embodiments

All patents, patent applications, including U.S. Provisional Application Nos. 61/225,486, 61/181,144, and 61/200,947, filed July 14, 2009, May 26, 2009, and

December 5, 2008, respectively, and publications mentioned in this specification are herein incorporated by reference to the same extent as if each independent patent, patent application, or publication was specifically and individually indicated to be incorporated by reference.

What is claimed is:

CLAIMS

1. A compound having the formula

A-X-B

wherein

A is a peptide vector comprising an amino acid sequence at least 70% identical to a sequence selected from the group consisting of SEQ ID NO:1-105 and 107-114, or a fragment thereof;

X is a linker; and

B is a peptide therapeutic selected from the group consisting of neurotensin, a neurotensin analog, or a neurotensin receptor agonist.

2. The compound of claim 1, wherein A is a polypeptide has an amino acid sequence at least 70% identical to a sequence selected from the group consisting of Angiopep-1 (SEQ ID NO:67), Angiopep-2 (SEQ ID NO:97), cys-Angiopep-2 (SEQ ID NO:113), and Angiopep-2-cys (SEQ ID NO:114).

3. The compound of claim 2, wherein said sequence identity is at least 90%.

4. The compound of claim 3, wherein said polypeptide comprises an amino acid sequence selected from the group consisting of Angiopep-1 (SEQ ID NO:67), Angiopep-2 (SEQ ID NO:97), cys-Angiopep-2 (SEQ ID NO:113), and Angiopep-2-cys (SEQ ID NO:114).

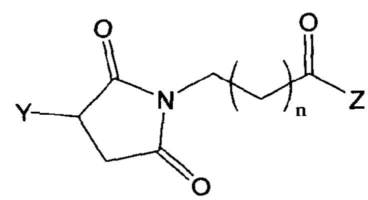
5. The compound of claim 4, wherein said polypeptide consists of an amino acid sequence selected from the group consisting of Angiopep-1 (SEQ ID NO:67), Angiopep-2 (SEQ ID NO:97), cys-Angiopep-2 (SEQ ID NO:113), and Angiopep-2-cys (SEQ ID NO:114).

6. The compound of any of claims 1-5, wherein B comprises human neurotensin, human neurotensin(8-13), Ac-Lys-[D-Tyr^{11}]NT(8-13), Ac-Lys-NT(8-13), pE-Lys-NT(8-13), or pELYENKPRRPYIL-OH, where pE represents L-pyroglutamic acid.

7. The compound of claim 6, wherein B is pELYENKPRRPYIL-OH.

8. The compound of claim 7, wherein A comprises Angiopep-1 (SEQ ID NO:67), Angiopep-2 (SEQ ID NO:97), cys-Angiopep-2 (SEQ ID NO:113), or Angiopep-2-cys (SEQ ID NO:114).

9. The compound of any of claims 1-8, wherein X has the formula:

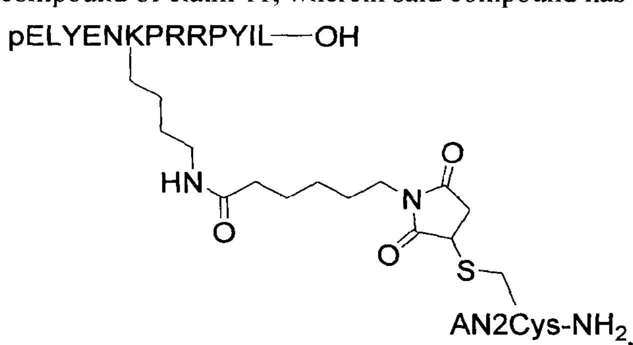


where n is an integer between 2 and 15; and either Y is a thiol on A and Z is a primary amine on B or Y is a thiol on B and Z is a primary amine on A.

10. The compound of claim 9, wherein n is 3, 6, or 11.

11. The compound of claim 10, wherein A is cys-AngioPep-2 (SEQ ID NO:113) or AngioPep-2-cys-NH_2 (SEQ of ID NO:114); and B is human neurotensin or pELYENKPRRPYIL-OH, where pE represents L-pyroglutamic acid, and Y is the thiol group on the cysteine of A, and Z is the ε-amine of Lys^6 of B.

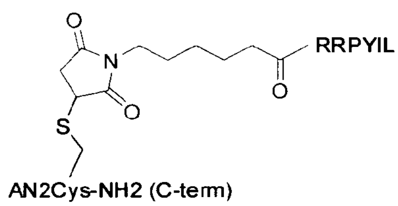
12. The compound of claim 11, wherein said compound has the structure



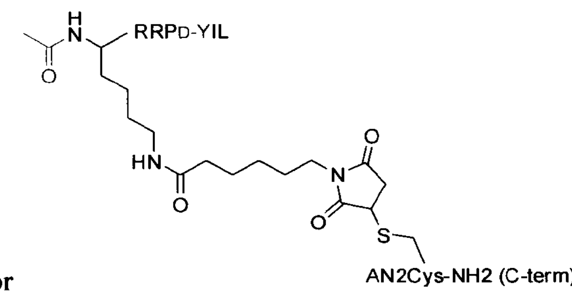
wherein the $-(CH_2)_4NH-$ moiety attached to the lysine of the pELYENKPRRPYIL sequence represents the side chain of that lysine, and the $-CH_2S-$ moiety attached to

the C-terminal cysteine of the AN2Cys sequence represents the side chain of that cysteine, and, further, wherein the C-terminal OH and NH_2 groups of the pELYENKPRRPYIL sequence and AN2Cys, respectively, indicate that the pELYENKPRRPYIL sequence has a C-terminal hydroxyl group and that the AN2Cys has a C-terminal amine group.

13. The compound of claim 1, wherein said compound has the structure



or



14. The compound of claim 1, wherein X is peptide bond.

15. The compound of claim 1, wherein X is at least one amino acid; and A and B are each covalently bonded to X by a peptide bond.

16. A nucleic acid molecule encoding the compound of claim 14 or 15.

17. A vector comprising the nucleic acid molecule of claim 16, wherein said nucleic acid is operably linked to a promoter.

18. A method of making a compound of claim 14 or 15, said method comprising expressing a polypeptide encoded by the vector of claim 17 in a cell, and purifying said polypeptide.

19. A method of making a compound of claim 14 or 15, said method comprising synthesizing said compound on solid support.

20. A method of reducing body temperature of a subject, said method comprising administering a compound of any of claims 1-15 in a sufficient amount to reduce body temperature.

21. The method of claim 20, wherein said subject is suffering from or has suffered from stroke, heart attack, cerebral ischemia, cardiac ischemia, or a nerve injury or is in need of neuroprotection.

22. The method of claim 21, wherein said nerve injury is a brain or spinal chord injury.

23. The method of claim 22, wherein said brain injury is a traumatic head or brain injury.

24. The method of claim 21, wherein said subject is undergoing or is about to undergo a surgical procedure.

25. The method of claim 24, wherein said surgical procedure is cardiac surgery or open heart surgery.

26. The method of claim 20, wherein said subject is suffering from malignant hypothermia.

27. A method of treating pain or prophylactically treating pain in a subject, said method comprising administering a compound of any of claims 1-15 in an amount sufficient to treat said pain.

28. The method of claim 27, wherein said pain is an acute pain selected from the group consisting of mechanical pain, heat pain, cold pain, ischemic pain, and chemical-induced pain.

29. The method of claim 27, wherein said pain is peripheral or central neuropathic pain, inflammatory pain, migraine-related pain, headache-related pain,

irritable bowel syndrome-related pain, fibromyalgia-related pain, arthritic pain, skeletal pain, joint pain, gastrointestinal pain, muscle pain, angina pain, facial pain, pelvic pain, claudication, postoperative pain, post traumatic pain, tension-type headache, obstetric pain, gynecological pain, or chemotherapy-induced pain.

30. A method of decreasing pain sensitivity in a subject, said method comprising administering an effective amount of a compound of any of claims 1- 15 to said subject.

31. A method of treating a subject having a psychotic disorder, said method comprising administering a compound of any of claims 1-15 in an amount sufficient to treat said disorder.

32. The method of claim 31, wherein said psychotic disorder is schizophrenia.

33. A method of treating drug addiction or drug abuse in a subject, said method comprising administering to said subject a compound of any of claims 1-15 in an amount sufficient to treat said addiction or abuse.

34. The method of claim 33, wherein said drug is a psychostimulant or is alcohol.

35. The method of claim 34, wherein said psychostimulant is selected from the group consisting of amphetamine, methamphetamine, 3,4-methylenedioxymethamphetamine, nicotine, cocaine, methylphenidate, and arecoline.

36. A method of treating a subject having a metabolic disorder, said method comprising administering a compound of any of claims 1-15 in an amount sufficient to treat said disorder.

37. The method of claim 36, wherein said amount sufficient is less than 50% of the amount required for an equivalent dose of the neurotensin agonist when not conjugated to the peptide vector.

38. The method of claim 37, wherein said amount is less than 15%.

39. The method of claim 36, wherein said metabolic disorder is diabetes, obesity, diabetes as a consequence of obesity, hyperglycemia, dyslipidemia, hypertriglyceridemia, syndrome X, insulin resistance, impaired glucose tolerance (IGT), diabetic dyslipidemia, hyperlipidemia, a cardiovascular disease, or hypertension.

40. A method of treating or treating prophylactically a neurological disorder in a subject, said method comprising administering a compound of any of claims 1-15 to said subject in an amount sufficient to treat or prevent said disorder.

41. The method of claim 40, wherein said neurological disorder is schizophrenia.

42. The method of claim 40, wherein said neurological disorder is obsessive-compulsive disorder or Tourette's syndrome.

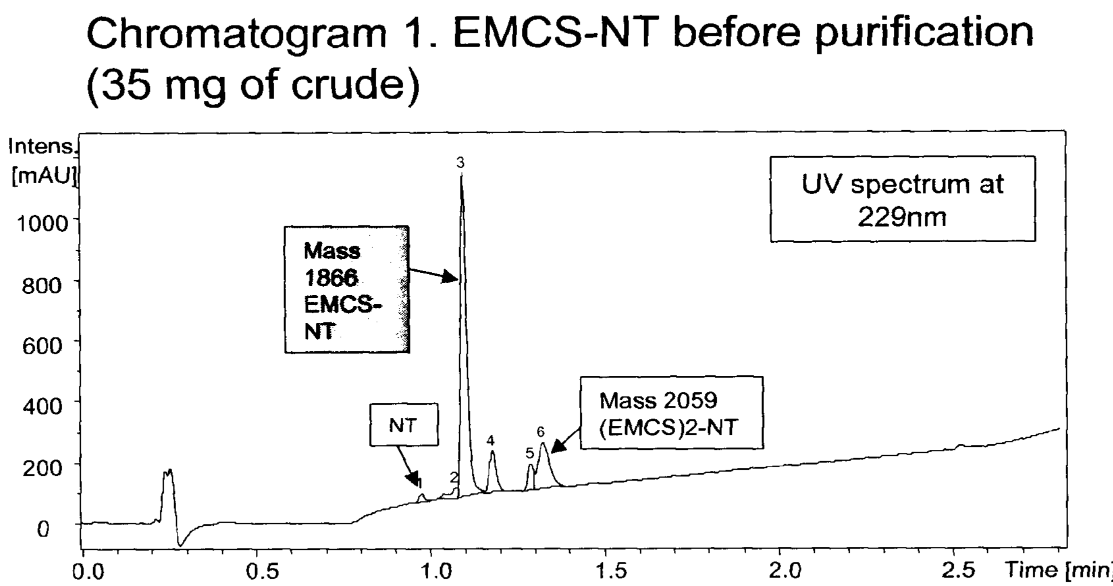


Figure 1A

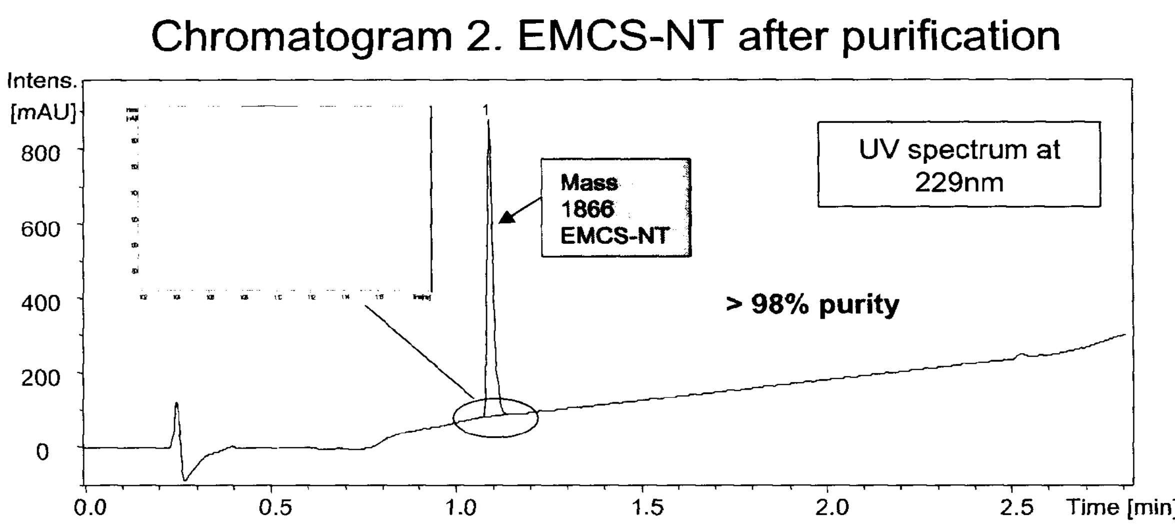


Figure 1B

Chromatogram 3. Purification of EMCS-NT on AKTA-explorer with column filled with 30 ml of 30RPC resin

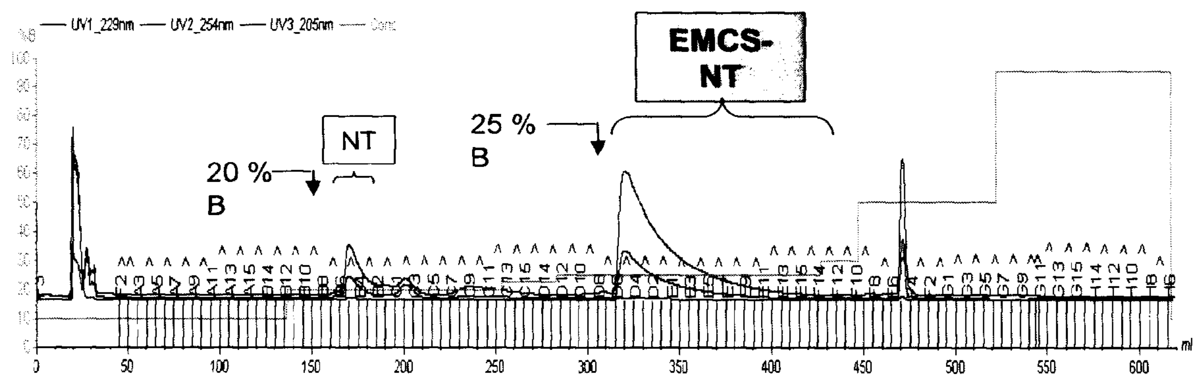


Figure 2

Chromatogram 4. NT-AN2Cys-NH_2 before purification

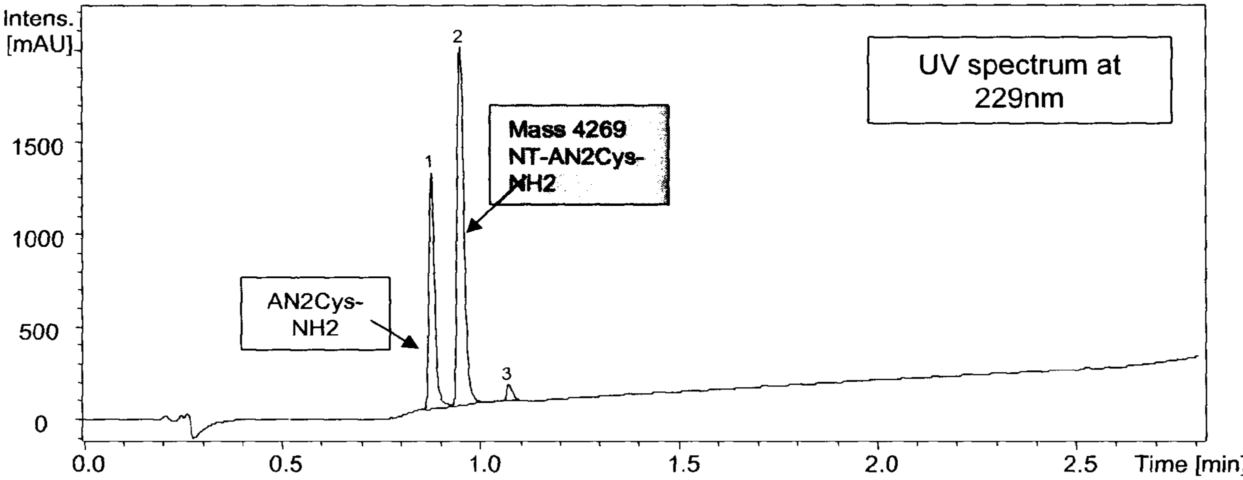


Figure 3A

Chromatogram 5. NT-AN2Cys-NH_2 after purification

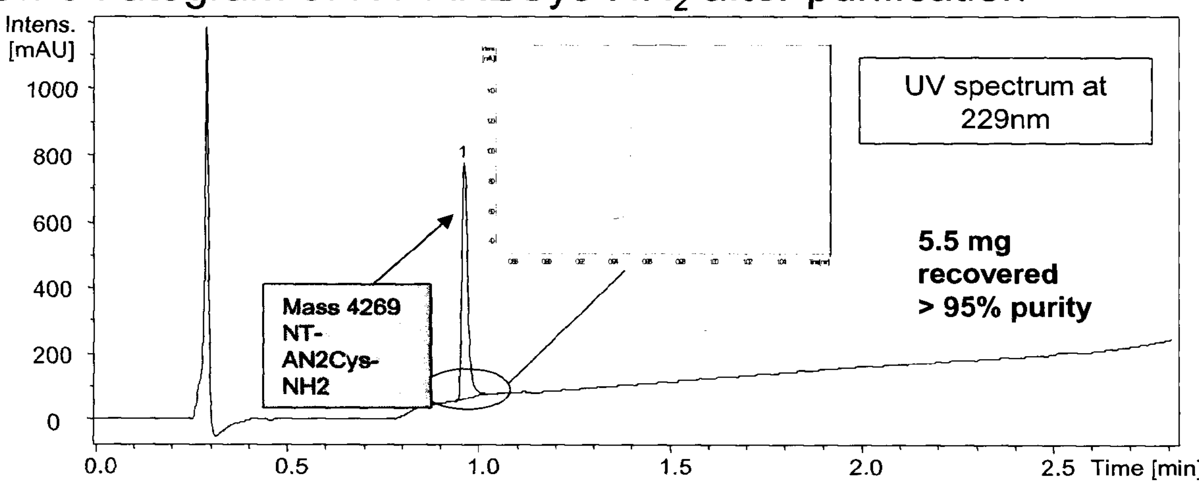


Figure 3B

Chromatogram 6. Purification of NT-AN2Cys-NH_2 on AKTA-explorer with column filled of 30mL of 30RPC resin

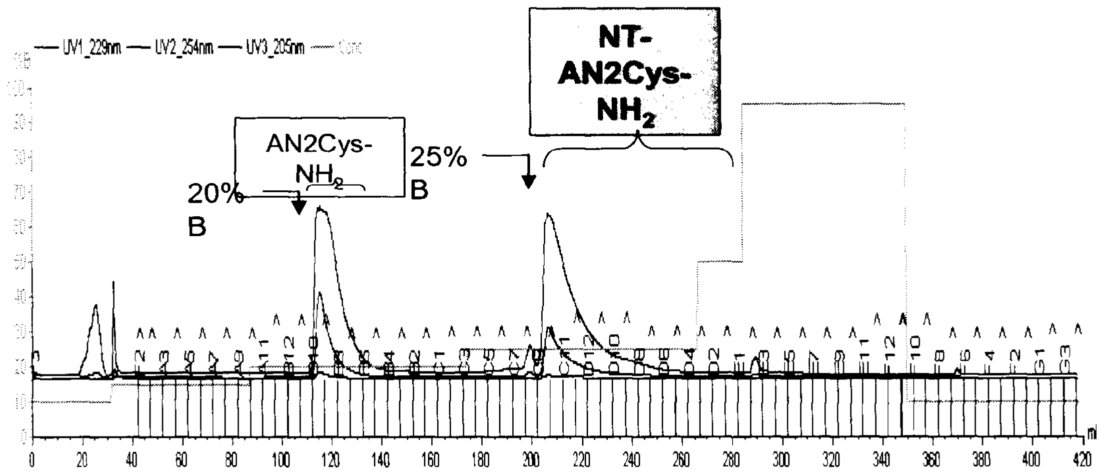


Figure 4

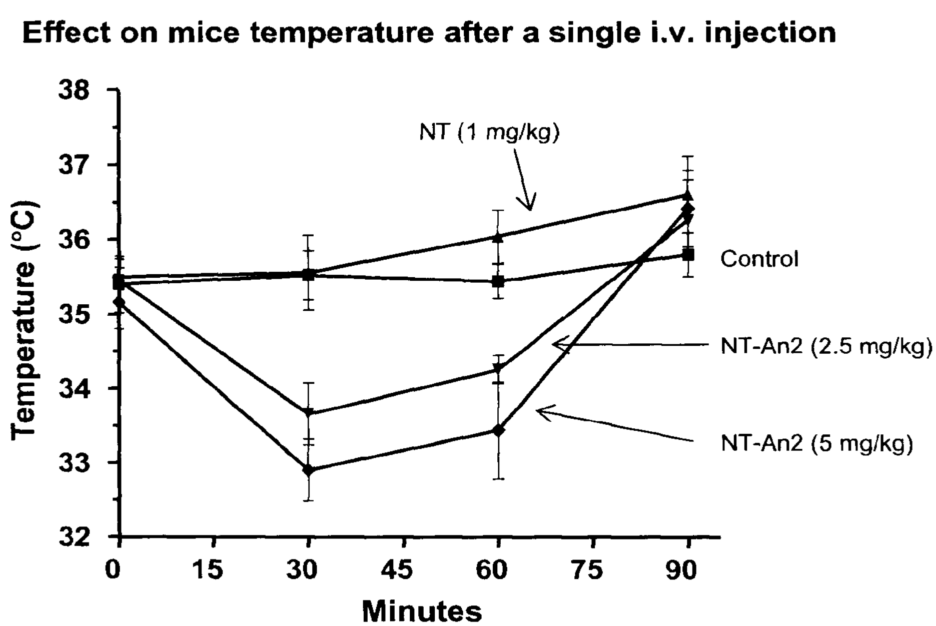


Figure 5

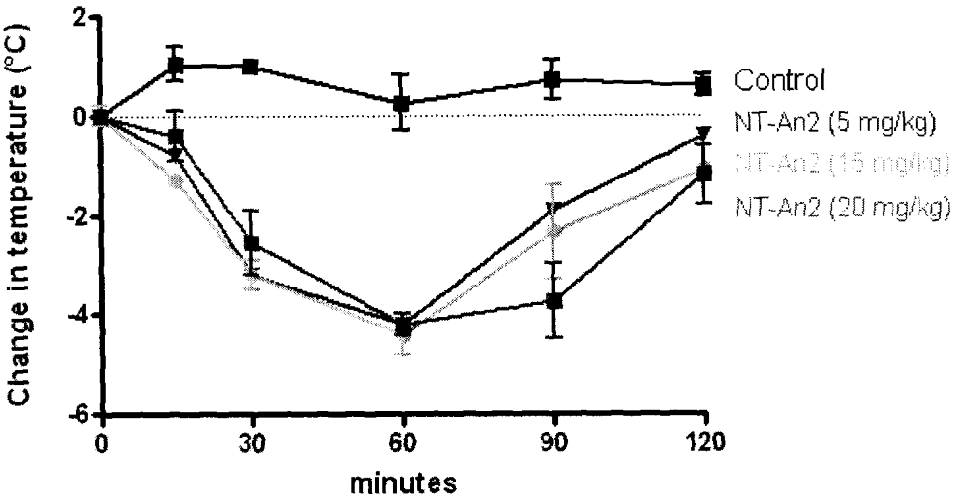


Figure 6

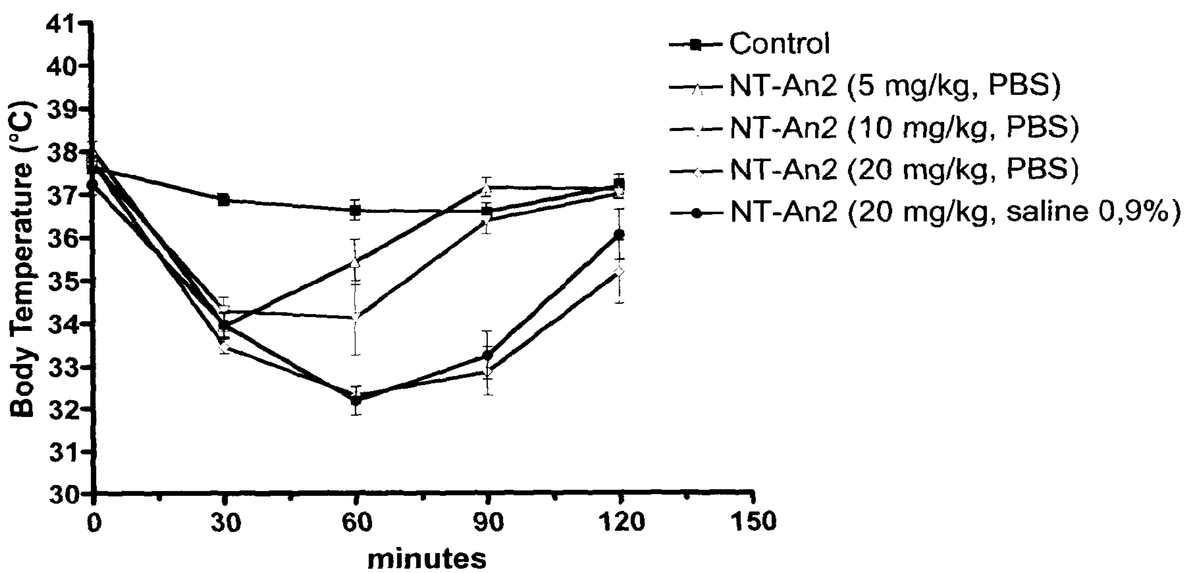


Figure 7

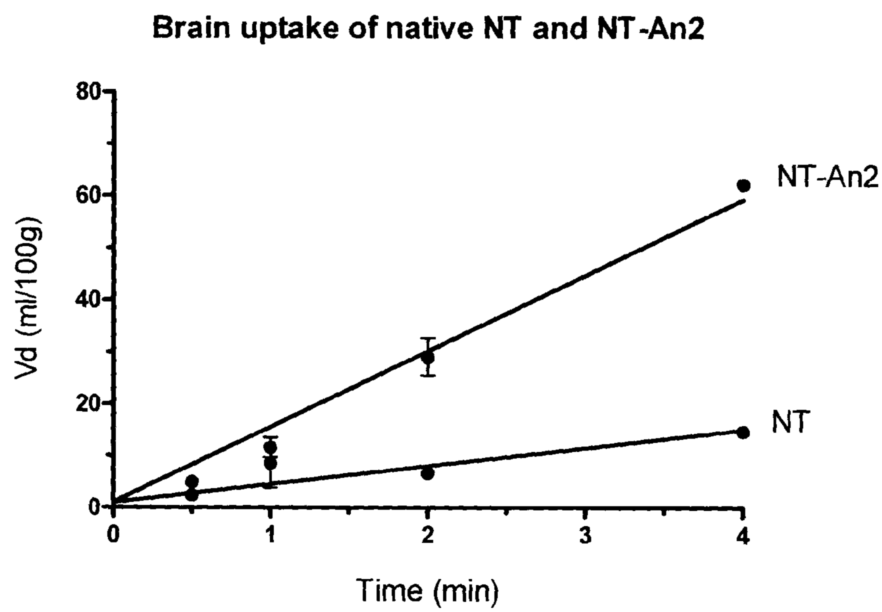


Figure 8

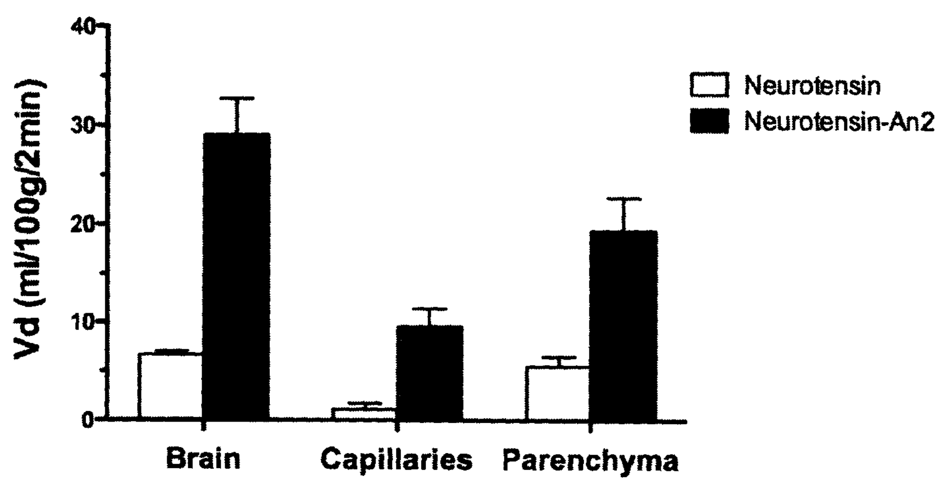


Figure 9

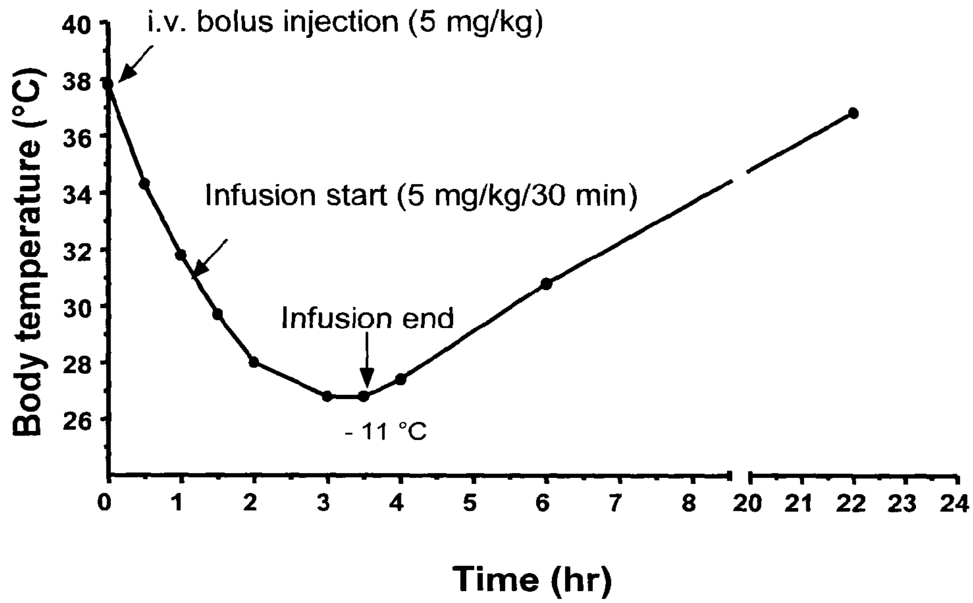


Figure 10

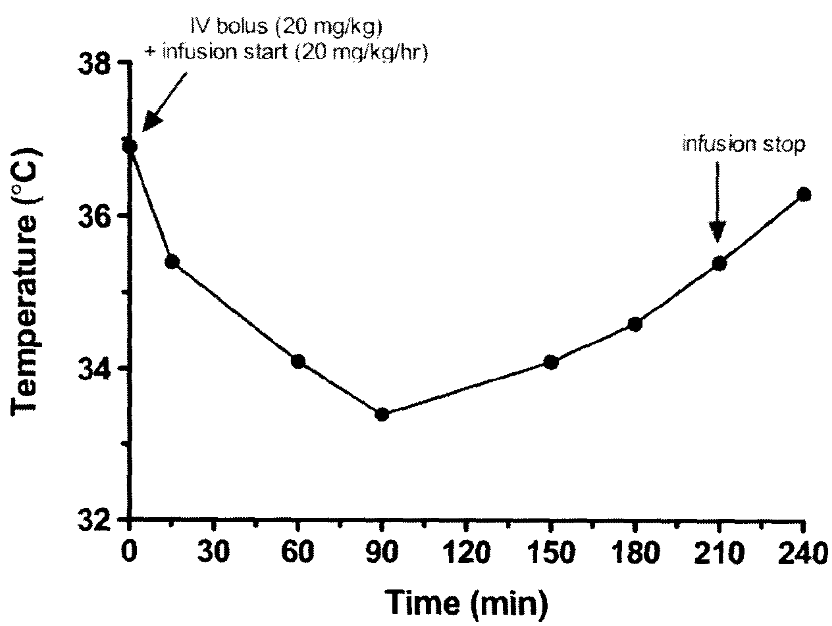


Figure 11

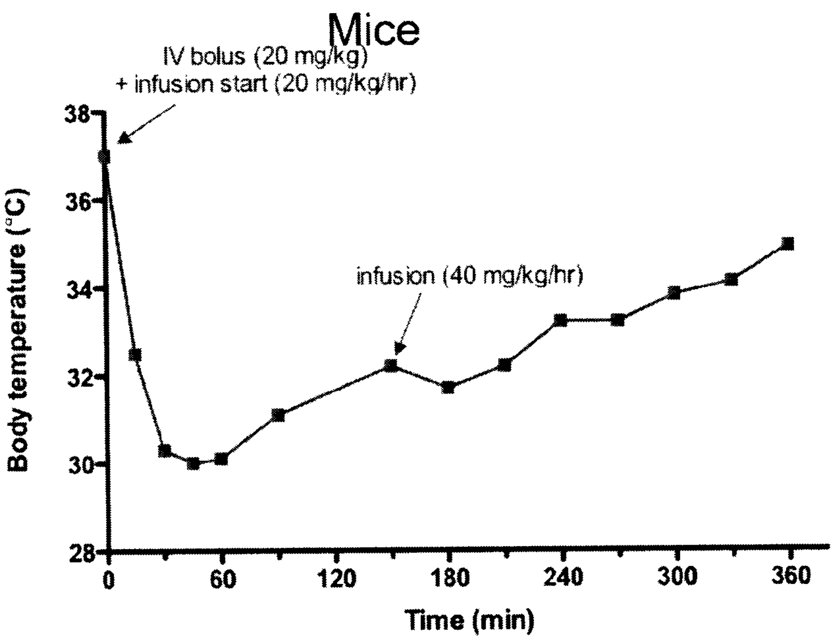


Figure 12

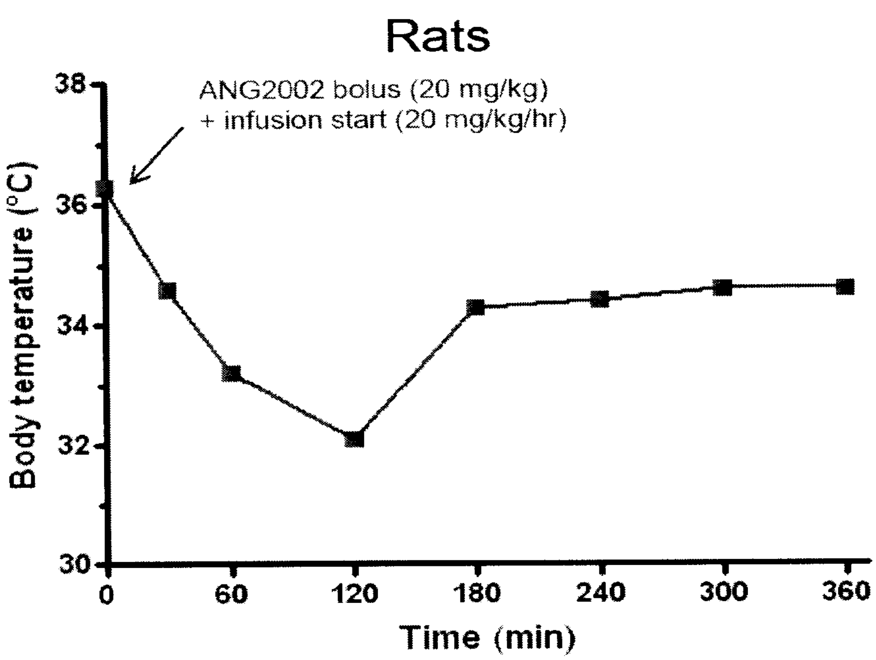


Figure 13

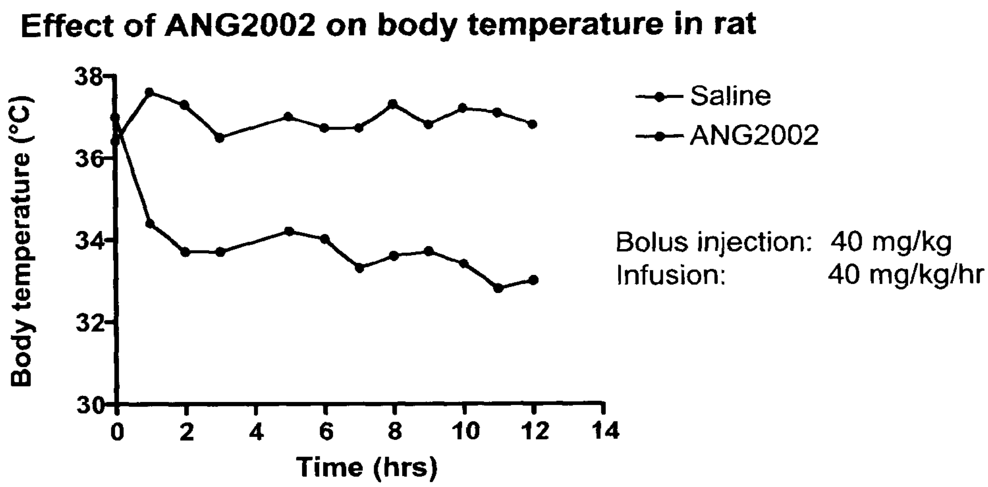


Figure 14

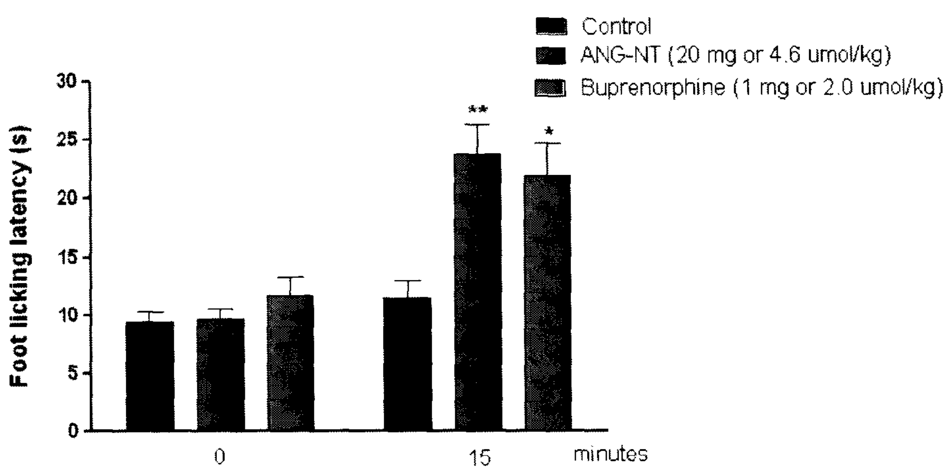


Figure 15

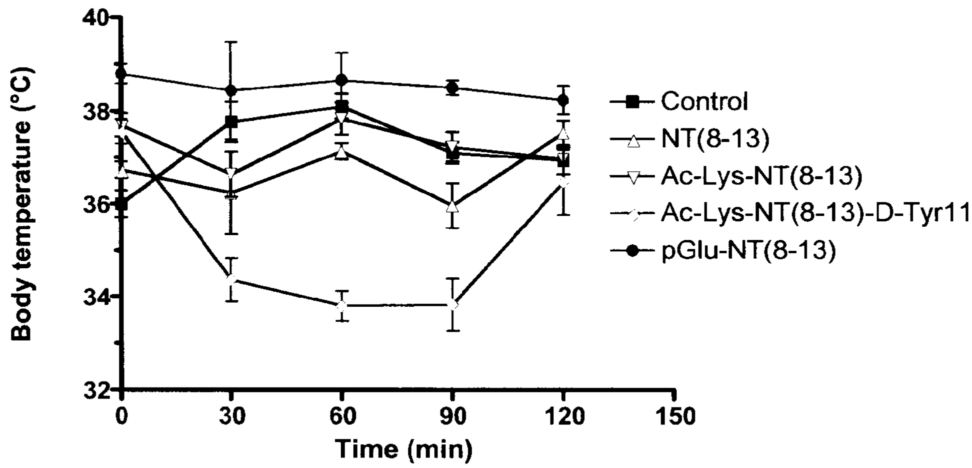


Figure 16

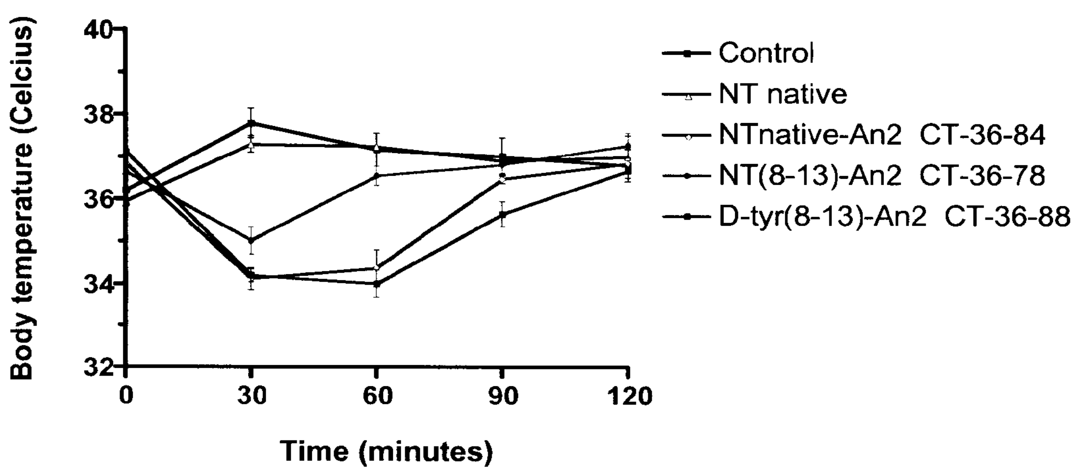


Figure 17

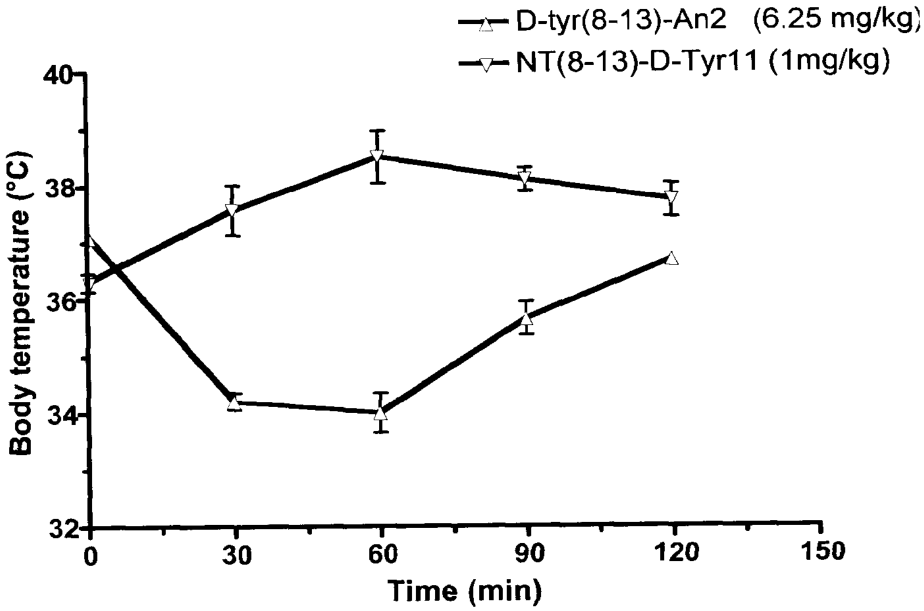


Figure 18

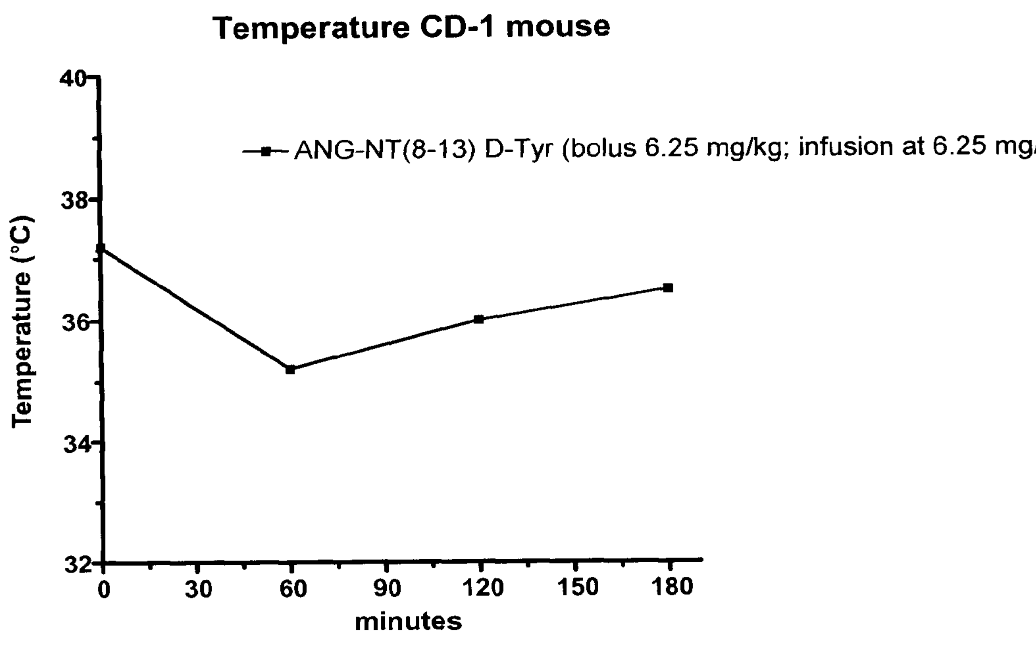


Figure 19

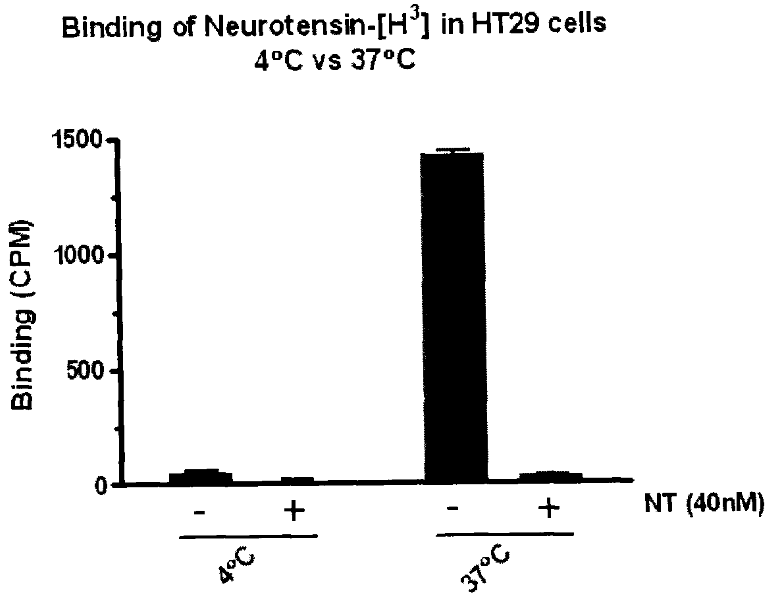


Figure 20

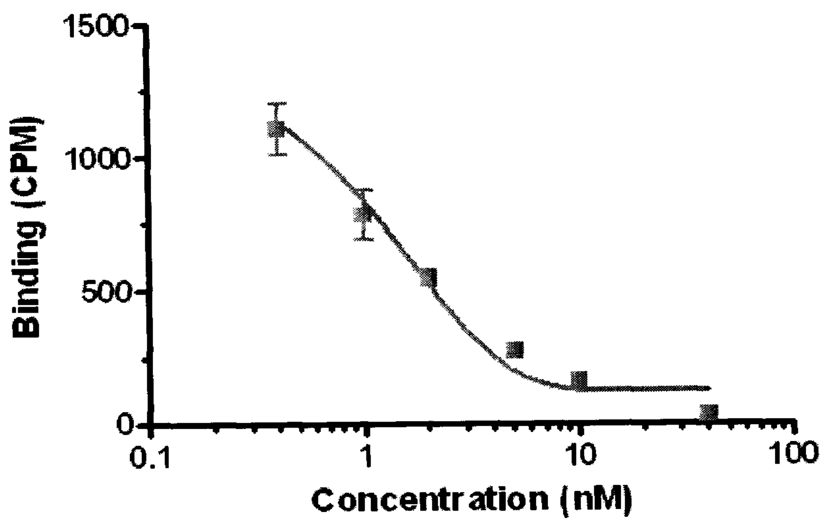


Figure 21

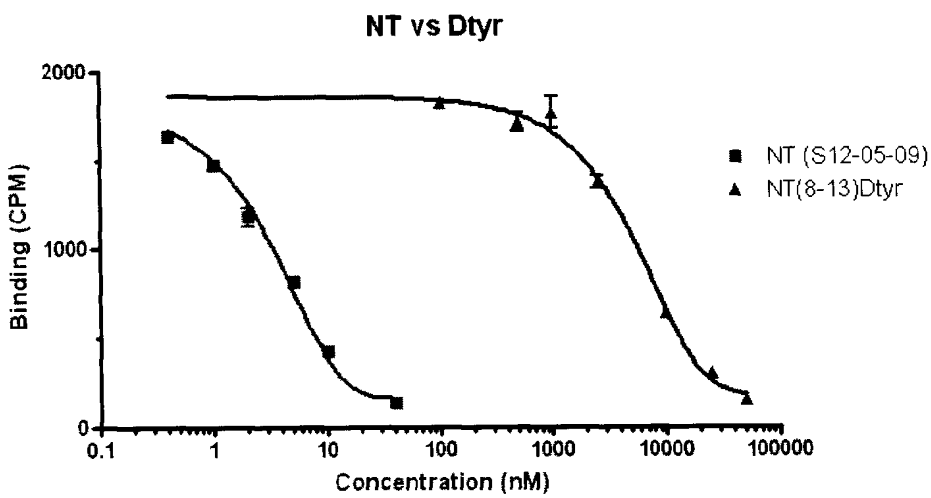

NT vs Dtyr
2000
1000
0
Binding (CPM)
0.1
1
10
100
1000
10000
100000
Concentration (nM)
NT (S12-05-09)
NT(8-13)Dtyr

Figure 22

Box No. I Nucleotide and/or amino acid sequence(s) (Continuation of item 1.c of the first sheet)

1. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of a sequence listing filed or furnished:

a. (means)

[ ] on paper

[X] in electronic form

b. (time)

[ ] in the international application as filed

[ ] together with the international application in electronic form

[X] subsequently to this Authority for the purposes of search

2. [ ] In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

3. Additional comments :

INTERNATIONAL SEARCH REPORT	International application No. PCT/CA2009/001779

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of the first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons :

1. [X] Claim Nos. : 20-42

   because they relate to subject matter not required to be searched by this Authority, namely :

   Claims 20-42 are directed to a method for treatment of the human or animal body by surgery or therapy which the International Search Authority is not required to search under Rule 39.1(iv) of the PCT. However, this Authority has carried out a search based on the alleged effects or purposes/uses of the product defined in claims 20-42.

2. [ ] Claim Nos. :

   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically :

3. [ ] Claim Nos. :

   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows :

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claim Nos. :

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim Nos. :

Remark on Protest [ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2009/001779

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***C07K 19/00*** (2006.01), ***A61K 38/16*** (2006.01), ***A61K 47/48*** (2006.01), ***C07K 7/08*** (2006.01), ***C12N 15/62*** (2006.01), ***C07K 14/81*** (2006.01), ***C07K 17/00*** (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07K 19/00 (2006.01), ***A61K 38/16*** (2006.01), ***A61K 47/48*** (2006.01), ***C07K 7/08*** (2006.01), ***C12N 15/62*** (2006.01), ***C07K 14/81*** (2006.01), ***C07K 17/00*** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Delphion, Scopus, PubMed, Google Scholar, ScienceDirect, Canadian Patent Database, GenomeQuest
Keywords: angiopep, neurotensin, blood brain barrier, brain, neurotensin analog(s), neurotensin D-Tyr^{11}, obesity, EMCS, Sulfo-EMCS, neurotensin review, Demeule, Che, Thiot, Gagnon, SEQ ID NOs: 1-105 and 107-114

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2008/144919 A1 (BELIVEAU, R. et al.) 4 December 2008 *pages 23-28, 42-43, 60-61, 69-71	1-36, 39-42
Y	BOULES, M. et al., Bioactive analogs of neurotensin: Focus on CNS effects, Peptides, October 2006, Vol. 27, No. 10, pages 2523-2533 ISSN 0196-9781 *entire document	1-36, 39-42

[ ] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 February 2010 (09-02-2010)	10 March 2010 (10-03-2010)

Name and mailing address of the ISA/CA
Canadian Intellectual Property Office
Place du Portage I, C114 - 1st Floor, Box PCT
50 Victoria Street
Gatineau, Quebec K1A 0C9
Facsimile No.: 001-819-953-2476

Authorized officer
Jessica Smith (819) 994-6977

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2009/001779

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
WO2008144919A1	04-12-2008	AU2005327497A1	24-08-2006
		AU2006272405A1	25-01-2007
		BRPI0520032A2	14-04-2009
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		EP1907009A4	02-09-2009
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		JP2009500431T	08-01-2009
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		US2009082277A1	26-03-2009
		WO2006086870A1	24-08-2006
		WO2007009229A1	25-01-2007
		ZA200706917A	29-10-2008